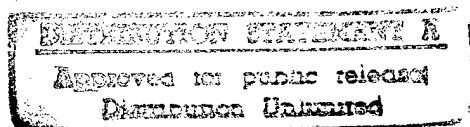


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# ***JPRS Report***



# **Science & Technology**

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# Science & Technology

## USSR: Materials Science

JPRS-UMS-89-002

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UDC 678.01.539.61

**Influence of Water on Adhesion Properties of Epoxy Coatings on Aluminum**

*18420087b Moscow ZASHCHITA METALLOV in Russian Vol 24 No 6, Nov-Dec 88 (manuscript received 28 Aug 87) pp 950-956*

[Article by V. V. Arslanov and V. Funke, Physical Chemistry Institute, USSR Academy of Sciences; Stuttgart University; Scientific Research Institute of Pigments and Varnishes, Stuttgart]

[Abstract] Two methods were compared for measuring the stability of adhesive joints exposed to water—delamination and tacky strip testing. Both methods revealed anomalous behavior of epoxy coatings bonded to aluminum when held in water. Adhesive strength was found to increase as a result of hydration of the oxide in the interphase zone of the adhesive joint. The mechanism of increased adhesive joint stability of the polymer with aluminum is discussed for various metal surface preparation and curing conditions. The tacky strip method was found to be suitable for quantitative determination of the stability of polymer coatings exposed to corrosive media. References 25: 5 Russian, 20 Western.

UDC 669.187.526:621.365.91:537.533:621.3.078

**Automatic Control System for Electron-Beam Coating Installation**

*18420100c Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGIYI in Russian No 4, Oct-Dec 88 (manuscript received 25 Mar 86) pp 57-62*

[Article by V. N. Vorobyev, V. P. Mishchenko, Yu. N. Lankin, and S. S. Tarasov, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences, Kiev]

[Abstract] A computer system for automatic control of an installation for electron-beam application of coatings has been developed at the authors' institute. The purpose of the system is to fully automate the technological cycle of the application of coatings in multiple-crucible electron-beam installations such as the UE-175. Tasks include control of the technological processes by acting on actuating mechanisms and the setting of automatic regulation devices; monitoring of the status of the equipment; measurement and testing of mode parameters; formation and output of operational messages on the results of system monitoring and self-testing; and printing of the record sheet and certificate of the finished products. A flow chart of the technological cycle of coating application is presented. The operation of the system in each stage is briefly described. The system

software is modular, including control and functional programs, 42 modules occupying a total of 16 kbytes of memory. References 8: 7 Russian, 1 Western.

UDC 621.762.01

**Liquid-Phase Compacting of Porous Sprayed Coatings**

*18420113a Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 88 (manuscript received 29 Jan 87) pp 26-31*

[Article by K. B. Bartanov and V. S. Ivashko, All-Union Correspondence Machine-Building Institute; BrNPO Scientific-Production Association for Powder Metallurgy]

[Abstract] Experiments were performed involving isothermal sintering of nickel self-fluxing flame-sprayed coatings 0.6-0.7 mm thick on specimens of type 40 steel. Specimens were held in a furnace at the sintering temperature, then cooled under a jet of air for 3-4 minutes. The porosity of the sintered coating was determined by studying cross sections through the thickness of the coating. The process is found to be heat-activated. The activation energy is determined from the isotherms. Tensile stress generated during heating causes incomplete healing of microscopic cracks and pores during sintering. Upon cooling, the thermoelastic tensile stresses cause the cracks to grow, leading to failure of the coatings. Study of photomicrographs of coatings of self-fluxing alloys on steel indicates that cracks develop at grain boundaries. References 4: all Russian.

UDC 669.018:536.24

**Performance of Coated Materials in High-Enthalpy Oxidative Gas Flows**

*18420077e Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY in Russian No 5, Sep-Oct 88 (manuscript received 24 Nov 87) pp 157-164*

[Article by P. D. Lebedev, A. G. Smolin, V. S. Terent'yeva, and N. V. Kholodkov, Moscow]

[Abstract] Since in most cases the conditions for working with coated materials in heat-loaded structural elements are so complex that full simulation in the stage of the working of coated specimens is not feasible, it is necessary to be able to vary the main parameters of the external effect. This article discusses examples of the analysis of the oxidizing capacity of a gas flow applicable to flight conditions for high-speed aircraft, air-breathing jet engines and tapered edges exposed to flows of air or fuel combustion products; i.e., the heat resistance of coated materials under conditions of their use in heat-loaded structural elements was studied. Particular attention is given to three types of interaction between oxidizing material and a gas flow (the operating state of

self-healing coating on material; worsening of the adhesion of the coating with the base material due to inadequate rate of growth of the oxide film; mechanical break-up of the coating due to an excess rate of growth of the oxide film). The apparatus used for reproducing external effect conditions and practical implementation of the external effects variation method are described. Diffusional and kinetic oxidation mechanisms are examined. Materials with pores and defects in the coating were tested. It is shown that evaluations of the performance of protective coatings on the basis of tests in stationary or low-velocity gas media is inadmissible when the coatings are used under conditions with high values of the heat exchange coefficients and pressure gradients. Performance checking must include laboratory tests under multiparameter simulation conditions. In computing the heating temperature of a material it is necessary to make allowance for local overheating in the case of material oxidation in a zone of defects. References 4: 3 Russian, 1 Western (in Russian translation).

UDC 621.891

**Antifriction Powder Materials for High-Speed Friction Units**

18420112b Kiev POROSHKOVAYA METALLURGIYA  
in Russian No 9, Sep 88 (manuscript received  
25 Sep 87) pp 29-38

[Article by N. G. Baranov, Institute of Materials Science Problems, Ukrainian Academy of Sciences]

[Abstract] This review of the western literature discusses techniques of manufacturing antifriction powder materials for high-speed friction couples. These materials are in great demand for missile and aircraft building, power engineering, chemical and petroleum machine building. Materials discussed include carbon-based materials, ceramic materials, polymer-based materials and metal-based composites. The literature indicates that all these classes of materials are presently in use, with the composition selected based on the functional purpose and operating conditions of the friction couple. References 59: all Western (29 in Russian translation).

UDC 621.762

**Changes in Mechanophysical Properties of  
 $TiB_2$ -Cu Composite Upon Heating**

18420120b Kiev POROSHKOVAYA METALLURGIYA  
in Russian No 1, Jan 89 (manuscript received  
13 May 87) pp 61-65

[Article by I. A. Varvus, B. G. Strongin, and V. I. Kopylov, Physical Mechanical Institute, UkrSSR Academy of Sciences, and Chernovtsy State University]

[Abstract] An experimental study of the 80  $TiB_2$  - 20 Cu powder composite produced by liquid-phase sintering was made, the purpose being to determine the causes of changes in its mechanical properties upon exposure to high temperature in an oxidizing medium. Its density and porosity, measured by hydrostatic weighing, were respectively  $4.605 \cdot 10^3$  kg/m<sup>3</sup> and 8 pct under normal conditions. Bar specimens of 15 mm gage length and 1x3 mm<sup>2</sup> in cross-section were tested for ultimate momentary strength in an "Ala-Too" (IMASh-20-71) machine under vacuum at various temperatures covering the 293-1073 K range, with the load applied at a rate of  $5.6 \cdot 10^{-2}$  mm/s. Bar specimens 40 mm long and 30x30 mm<sup>2</sup> in cross-section were tested for the dynamic moduli of elasticity and rigidity by the high-frequency echopulse method at 10 MHz at room temperature, the two moduli and the Poisson ratio of this material in the original state being  $32.1 \cdot 10^4$  MPa,  $12.6 \cdot 10^4$  MPa, and 0.27 respectively. Bar specimens 50 mm long and 1x1 mm<sup>2</sup> in cross-section were tested for inelastic characteristics and the temperature dependence of the relaxational modulus of rigidity under vacuum in a low-frequency relaxator. Differential thermal and thermogravimetric analyses were performed in a Q-1500 derivatograph, phase analysis was performed in a DRON-2 x-ray diffractometer with CuK<sub>alpha</sub> and FeK<sub>alpha</sub> radiation sources, specimens for these analyses having been prepared by electric-spark cutting in kerosene. The results of the study indicate a rapid loss of strength with rising temperature and eventual brittle fracture. The small difference between relaxational and dynamic moduli of rigidity is attributable not only to the precision of measurements but also to the scattering of elastic energy by defects in the crystal lattice. Measurements of internal friction revealed changes at 693, 823, 953, and 1053 K temperatures attributable to inelastic phase transformations, the first two peaks vanishing upon reheating and the last peak at 1053 K coinciding with an anomalous jump of the relaxational modulus of rigidity. Phase analysis after temperature cycling under vacuum did not reveal new reflexes in addition to those characterizing the  $TiB_2$  and Cu lattices. Measurements in air were unsuccessful, increasingly strong internal friction masking characteristic phase effects at temperatures from 700 K up. An oxidation mechanism is proposed on the basis of the various data which consists of four stages: 1) the Cu binder oxides first, at 700 K; 2)  $TiB_2$  oxides next, forming TiO and a protective  $B_2O_3$  film, at

810 K; 3) Cu and  $B_2O_3$  form  $Cu_3(BO_3)_2$  at 900 K and more oxygen begins to penetrate; 4) TiO oxidizes to  $TiO_2$  at 1070 K. References 6: 5 Russian, 1 Western (in Russian translation).

**Electron-Plastic Effect's Uses in Obtaining  
Composite Materials**

18420081a Moscow SOTSIALISTICHESKAYA  
INDUSTRYIA in Russian 1 Dec 88 p 4

[Article by Ye. Kolesnikova]

[Excerpt] "When I was a graduate student, I conducted experiments with an electron accelerator," recalled Doctor of Technical Sciences Oleg Aleksandrovich Troitskiy, head of the chair of physics of the Moscow Institute of Chemical Machine Building. "I was studying how radiation affects the strength and plasticity of metals. As soon as specimens began to break down, I switched off the accelerator and made the necessary measurements. I suddenly noticed that the plasticity of metal increased substantially when specimens in an electron beam were arranged in a certain manner."

The electron-plastic effect was thus discovered.

Its essence is as follows. As is known, metals have a crystalline structure. Crystals have always been a symbol of order—all of their atoms are arranged in a certain sequence. But ideal perfection obviously does not exist in nature; defects such as dislocations (lines near which the regular arrangement of atomic planes is disturbed) form in crystals.

If a mechanical force is applied to a specimen—e.g., if it is forged, rolled, or worked in some other manner—dislocations will begin to move. The more freely they move, the more plastic the metal.

"The atomic lattice in a crystal is capable of displacement at a very high speed, approximately the speed of sound," continued Oleg Aleksandrovich. "It was found, however, that this movement can be accelerated, and then plasticity increases."

There are always many free electrons in a metal. Through the action of an electric current, these electrons, like a wind, rush in one direction and move dislocations from their places.

The effect which Troitskiy discovered makes it possible to increase the plasticity of copper by tens of times, for example. Incredibly fine wire can be made which will not break. Tungsten, which is refractory and does not deform well, becomes twice as plastic.

Introduction of the electron-plastic effect makes it possible not only to improve the quality of products and simplify their production but also to obtain composite materials by enclosing copper, molybdenum or tungsten in an extremely thin sheath.

Oleg Aleksandrovich and his colleagues have extensive plans. They want to equip a whole line for producing welding wire at a complex in West Siberia.

UDC 621.762.5001

### **Kinetics of Sintering Dispersed Molybdenum-Copper Composites**

*18420112a Kiev POROSHKOVAYA METALLURGIYA  
in Russian No 9, Sep 88 (manuscript received 10 Jul 87)  
pp 13-16*

[Article by T. Ye. Landau, I. V. Uvarova, and V. V. Skorokhod, Institute of Materials Science Problems, Ukrainian Academy of Sciences]

[Abstract] An attempt was made to increase the dispersion of a pseudoalloy composite and the homogeneity of the distribution of its components by intensive grinding of industrial powders. The kinetics of sintering of the

powders was studied in comparison with mixtures obtained by simultaneous reduction of oxides. Three compositions were used: molybdenum-copper obtained by reducing the chemical compound (1); a reduced mixture of the oxides CuO and MoO<sub>3</sub> (2); and a mixture of commercial molybdenum and copper powders made in a hard alloy drum mill over 40 hours (3). The greatest activity in both solid and liquid-phase sintering is that of specimens of mixtures with matrix distribution of copper with respect to molybdenum and a low-melting component content of 40 percent. Specimens of the powder mixture (3) show no volumetric shrinkage during solid-phase sintering. Zonal isolation and separations between individual sections were observed. The heterogeneous structure formed influences the course of liquid-phase sintering and prevents active regrouping. The compact pseudoalloy was obtained after low-temperature liquid-phase sintering (1150°C) only with a 40 percent content of lower-melting phase by mass. References 5: 4 Russian, 1 Western (in Russian translation).

**Use of Carbonizers in Open-Hearth Smelting for Reducing Pig Iron Expenditure**

18420076a Moscow METALLURG in Russian  
No 10, Oct 88 pp 40-42

[Article by L. Yu. Nazyuta, G. Z. Gizatulin, A. M. Ovsyannikov, B. L. Kuzminykh, and V. A. Rubtsov, Zhdanov Metallurgical Institute; Combine imeni Ilich]

[Abstract] The expenditure of fluid pig iron in the smelting of steel in the open-hearth furnaces at the Combine imeni Ilich is one of the lowest in the industry. A reduction in the expenditure of fluid pig iron by 9.2 percent since 1983 has been achieved largely due to the use of secondary carbon-containing materials (discarded carbon linings and rejected anodes of aluminum electrolyzers, carbon-containing wastes of the abrasives industry) as a solid fuel and additional heat carrier. Three years of experience of work with these different materials has revealed that an obligatory condition for the normal course of the process is the proper charging of the melt. The greatest saving of fluid pig iron (4.2 tons/ton of carbonizer) is attained when using wastes from the abrasives industry with a relatively high (60-75 percent) carbon content, with a high dispersion of phases (40-50 percent of the material has pieces measuring 2-10 mm) and also containing 5-30 percent crystalline silicon carbide. The other carbonizers were inferior: rejected anodes containing 90-95 percent carbon, as a result of the lower degree of assimilation due to the presence of large particles, discarded carbon lining—due to the inadequate carbon content (40-80 percent). However, all the used materials are quite effective and make it possible to save fluid pig iron by an improvement in the heat balance of the process. The procedures used are described. The dynamics of slag formation are analyzed. All these carbonizers are of secondary origin. Because of this their cost is considerably lower than the cost of traditional carbonizers (coal, coke and graphite) and therefore the cost of the steel is reduced.

UDC 625.785:620.186.82

**Influence of Cooling Conditions in Thermocyclic Processing on Grain Size Reduction in Austenitic Steel**

18420062b Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV  
in Russian No 10, Oct 88 pp 22-24

[Article by Yu. A. Bashin, L. A. Lisitskaya, L. P. Frantsuzova, S. V. Semenov, B. V. Radziyevskiy, Moscow Evening Metallurgical Institute; VNIITMASH Scientific Production Association]

[Abstract] A thermocyclic processing (TCP) regime was developed earlier for grain size reduction in austenitic steel. It involves slow heating to the upper limit (UL) of the cycle, 880°C, followed by slow cooling. This makes it possible to reduce the grain size in austenitic steel in five TCP cycles to No 11 and to increase impact strength by

a factor of 2 in comparison with this parameter after holding at this same temperature. All specimens of 20Kh steel were heated simultaneously in a laboratory electric furnace to 880°C at a rate of 5-10 K/min and then cooled at different rates in water, in the air and in the furnace (10, 50, 100, 120 K/min). One to five TCP cycles were carried out. Austenite grain size was determined after each cycle. It was found that austenite grain size after TCP of 20Kh steel is dependent on the rate of cooling from the cycle's UL. A TCP with slow heating and cooling from the UL at rates of 10-100 K/min makes it possible to reduce the size of an austenite grain from No 4 to No 11-12. References 6: all Russian.

UDC 539.43:621.048.7

**Influence of Surface Relief of Laser Hardening on Cyclic Strength of Steel 45**

18420062d METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV  
in Russian No 10, Oct 88 pp 34-36

[Article by V. Ya. Mitin, Ye. I. Tesker, and V. A. Gurev, Volgogradskiy Zavod Production Association; Volgograd Polytechnic Institute]

[Abstract] Data in the literature on the influence of laser thermal hardening on fatigue strength are contradictory. However, an analysis of the research results indicates that an important factor exerting an influence on specimen fatigue is the surface position of metal sectors treated by laser radiation. A study was therefore made of the influence of the relief of laser-hardened sectors on the destruction mechanism and on longevity during the cyclic loading of standard cylindrical specimens with a diameter of 10 mm fabricated from normalized steel 45. A CO<sub>2</sub> laser was used. The reflectivity was reduced by covering the surface to be treated by a special light-absorbing coating with a thickness of 10 μm. Four irradiation schemes were examined: along the generatrix of the cylinder; circular; spiral; crisscross. The results of the fatigue tests are given for these different variants; surface layer structure and microhardness were also investigated. The longevity of the specimens is dependent on the scheme for treating the surface by laser radiation. The minimal fatigue strength is exhibited by specimens treated with movement of the laser ray along the generatrix of the cylinder; in the process of the cyclic loading of such specimens a great number of fatigue cracks, situated in the zones of laser treatment, are formed. In spiral treatment fatigue destruction for the most part occurs with the development of a crack from a single focus. With irradiation along the generatrix destruction occurs from several fatigue cracks developing from different foci situated in the immediate neighborhood of one another, both at the surface and at some distance

from it. Different laser thermal treatment schemes therefore make it possible to obtain a definite relief of hardened sectors on the specimen surface. References 6: all Russian.

UDC 620.18:620.17:669.14.018.8

### **Structure and Properties of 20Kh13 Steel After Laser Treatment**

*18420062e Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 10, Oct 88 pp 36-39*

[Article by Yu. M. Lakhtin, T. V. Gulyayeva, T. V. Tarasova, A. I. Syrovatkin, and M. B. Chizhmakov]

[Abstract] A study was made of the structure and properties of corrosion-resistant chrome steel 20Kh13 after laser heat treatment and laser alloying for determination of the dependence between the structure and properties of this steel and also for determination of the laser alloying mechanism. Laser heat treatment and laser siliconizing are promising methods for increasing the hardness, resistance to corrosion and resistance to wear of 20Kh13 steel in comparison with similar characteristics after ordinary heat treatment. This is attributable to the peculiarities of structure formation as a result of laser treatment. In laser heat treatment using pulsed and continuous radiation there was no significant difference in the phase composition and properties of the hardened zones. However, there is an insignificant increase in hardness in the case of pulsed radiation; this is attributable to the formation of a more dispersed structure. The laser alloying of 20Kh13 steel by a pulsed radiation source made it possible to obtain a better combination of properties in comparison with laser heat treatment due to the saturation of the surface layers with silicon. The high degree of homogeneity of the composition of 20Kh13 steel resulting from laser alloying is attributable for the most part to the intensive circulation and mixing of the melt. References 5: all Russian.

UDC 539.374:539.26

### **X-Ray Determination of the Technical Plasticity of Steels**

*18420078a Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 54 No 10, Oct 88 pp 33-35*

[Article by V. D. Kalner, A. N. Ivanov, and A. Ye. Ostrov]

[Abstract] Since some parts produced with cold die forging are rejected because the initial material does not have enough plasticity, a fast, nondestructive method of determining the plasticity of, say, steels used for cold upsetting is needed. The researchers used relative uniform elongation  $\delta_e$  in tensile testing to derive a formula to determine technical plasticity, based on the fact that, with tension, the stress state diagram is close to that that is found in drawing and cold die forging. Since the

elongation is directly dependent on the mean dislocation free path length  $l$ , and, in the initial state, material used for cold upsetting varies little in terms of chemical composition and microstructure,  $l$  (and, thus, the elongation) can be determined by the initial dislocation density  $Q_0$ . According to existing theory,  $l$  is approximately equal to  $Q_0^{-m}$ , where  $m$  varies from  $\frac{1}{2}$  to 1. For chaotically distributed dislocations, the physical broadening of the x-ray line  $B$  is approximately equal to  $Q_0^{1/2} t_{g_0}$ . Thus, using the functional dependences of  $l$  being approximately equal to  $Q_0^{-m}$ ,  $\delta_e$  being approximately equal to  $l$ , and  $B$  being approximately equal to  $Q_0^{1/2}$ , one can derive a correlation between the elongation and the broadening of the x-ray line in which  $\delta_e$  is approximately equal to  $B^n$ , where  $n = 1-2$ . The researchers derived numerical values for steel grades 35, 40Kh, and 40KhN, which are used at the ZIL production association, in order to determine the condition of rods upon receipt and after drawing deformation of 10-5%.  $B$  was isolated for line 211 for each sample, and the rods were tensile tested and  $\delta_e$  determined from the stress state diagram. The use of the correlation between  $\delta_e$  and  $B$  made it possible to determine that when  $\delta_e$  is less than or equal to 2.5%, the technical plasticity of 40Kh rods in cold upsetting is unsatisfactory. For other steels and other materials, the correlation between  $\delta_e$  and  $B$  holds up, but the numerical values will be different and require further experimentation. One figure, 8 references (Russian).

UDC 539.27

### **Technique for Analyzing the Patterns of $\gamma$ -to- $\alpha$ Deformation Shear Transformation in Steels**

*18420078b Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 54 No 10, Oct 88 pp 42-45*

[Article by Yu. R. Nemirovskiy and M. R. Nemirovskaya, Ural Polytechnical Institute imeni S. M. Kirov, Sverdlovsk]

[Abstract] Since the work of external load factors associated with the forming that accompanies the formation of martensitic  $\alpha$ -crystals can determine the probability of the appearance of specific  $\alpha$ -martensite crystal orientations in unstable austenite steels with  $\gamma$ -to- $\alpha$  deformation shear transformation, the researchers examine a technique for evaluating the role of that work in  $\gamma$ -to- $\alpha$  deformation shear transformation in steels with different types of  $\alpha$ -martensite. The method they use is based on a comparison of calculated pole figures and the experimentally derived distribution of directions of uniaxial deformation, elongation or compression along which leads to the appearance of crystals of a deformation  $\alpha$ -martensite. The pole figures used by the researchers display the direction of action of the external load factor for analysis of  $\gamma$ -to- $\alpha$  transformation with 15.3.10 $_\gamma$  and 522 $_\gamma$   $\alpha$ -martensites. In elongation,  $\alpha$ -crystals appeared for which the values for the work of the external load due to forming were relatively large, indicating the need to allow for external load factor work in the  $\gamma$ -to- $\alpha$  deformation shear transformation. The determining role of

that work is confirmed when the  $\alpha$ -crystals that appear in specific austenite grains are predominately those for which the external load factor work had the highest possible value. Asymmetry of arrangement of the poles of the distribution of the directions of uniaxial deformation relative to  $P_2 = \text{const}$  lines is virtually nonexistent, which is practically unavoidable when additional factors have any appreciable influence on deformation shear transformation. The determining role of the interaction between external load factor and forming due to martensitic transformation in the  $\gamma$ -to- $\alpha$  transformation is thus confirmed for elongation deformation in steels such as 50N29. In compression and elongation, similar deformation shear transformation correlations are found when the results for 40Kh9N6M4S2G1 steel with 52%  $\alpha$ -martensite are examined. Two figures, 7 references: 3 Russian, 4 Western.

UDC 620.171.2:621.746.019

#### Methods of Testing and Evaluating the Quality of a Large, High-Strength Steel Casting With an Initial Defect

18420078c Moscow ZAVODSKAYA LABORATORIYA  
in Russian Vol 54 No 10, Oct 88 pp 64-69

[Article by N. A. Makhutov, S. K. Ginzburg, A. I. Tananov, and I. I. Koksharov]

[Abstract] The quality of machine tool products depends to a large extent on the use of high-strength steels and advanced technologies for manufacturing parts and structural elements made from them. Cast steels are strong and reliable because of the complexity of their alloy, but that same complexity of alloy also increases the probability of intergrain defects, which reduce plasticity and strength under static loading. Regulating deoxidation and crystallization conditions of a steel to completely suppress the processes that lead to intergrain defects can be done in only relatively thin sections. High-strength cast 08N6G4ML steel, double normalized, has the structure of low-carbon martensite. Intergrain defects do not usually form in castings of this steel made in open arc melting, with a thickness of up to 70 mm. But matching the mechanical properties of a casting to the specified requirements in specimens blanked from standard wedges no thicker than 70 mm or directly from castings does not eliminate the possibility of the presence of cracks. The authors conclude that determining mechanical properties in tests of standard thin-section specimens is not enough to evaluate the quality of large cast steel structural elements with initial metal defects. Testing of full-scale specimens makes it possible to provide a more accurate evaluation of the quality of the casting. The researchers also conclude that statistical analysis of the size of a defect and of the total area it occupies is necessary for evaluating the serviceability of cast structures. Nondestructive defectoscopy or destruction of samples may be used to obtain such data. In

castings with intergrain defects, crack-resistance characteristics must be determined, as well as their relationship to the presence of defects. Eight figures, 3 references (Russian).

#### Optimizing the Composition of a Lubricant for Copper-Steel Friction Units

18420078d Moscow ZAVODSKAYA LABORATORIYA  
in Russian Vol 54 No 10, Oct 88 pp 97-98

[Article by A. A. Tuvin, Ivanovo Textile Institute imeni M. V. Frunze]

[Abstract] A sequential simplex-planning method was used to find the optimal composition of a lubricant that effected selective transfer in a copper-steel friction pair. Tests determining friction and wear characteristics were done on an assembly with a cone-bushing friction unit, the bushing made of Br OTsS-5-5-5 bronze and the cone made of ShKh-15 steel. Several experiments created a so-called second-order simplex-summable, rotatable configuration consisting of six points around a center. The response surface in the region of the extremum is an elliptical paraboloid. Movement away from the center leads to a worsening of the friction and wear characteristics of the bronze piece. The wear in the bronze piece was considerably less with the selective-transfer compound than with I-40A lubricating oil. The friction coefficient for the bronze piece lubricated with the selective-transfer compound was initially uneven, but smoothed out after 1 km. Three figures.

UDC 621.771.23:621.77.016.3

#### Improving Quality of Cold-Rolled Corrosion-Resistant Type 08Kh18T1 Steel

18420075a Moscow STAL in Russian  
No 9, Sep 88 pp 48-50

[Article by L. A. Agishev, A. I. Grishkov, A. R. Fisher, N. S. Kolesnikov, and B. N. Shapovalov, Chelyabinsk Metallurgical Combine; Central Scientific Research Institute of Ferrous Metallurgy]

[Abstract] A technology has been developed for production of cold-rolled nickel-free corrosion-resistant type 08Kh18T1 steel, involving melting in 100-ton electric-arc furnaces, pouring into 10.7-ton ingots which are heated for 8-9 hours to 1100-1120°C. To avoid cracking, 140×1080×4000 mm slabs are slowly cooled in unheated pits for 13-19 hours, then annealed at 750°C no more than 24 hours after the slow cooling, with the initial annealing temperature at least 200°C and the heating rate not over 100 K/hr. After holding, the metal is cooled with the furnace to 600°C and then in air. Defects are ground from the surface at 100-200°C. Limiting the temperatures of hot rolling is found to increase ductility

of the rolled product and of the cold-rolled sheets made from it, while decreasing metal consumption in the manufacture of the cold-rolled sheets.

UDC 621.98.011.4

**Noncontact Magnetic Sensors To Monitor Rolling and Sheet Steel Properties**

*18420075b Moscow STAL in Russian*  
*No 9, Sep 88 pp 53-57*

[Article by Yu. D. Zhelezov and A. G. Zhuravskiy, Moscow Steel and Alloys Institute; Lipetsk Polytechnical Institute]

[Abstract] Noncontact magnetic sensors can be used to certify products as to stampability, both during production and during consumer acceptance testing. The stampability of thin-sheet steel can be tested by measuring induction and its anisotropy in weak or moderate fields. A controller has been developed for nondestructive continuous testing of moving strip, capable of certifying practically the entire strip and real-time control of the technological process. The controller includes three sensors distributed across the width of the strip, with magnetization windings powered by a stabilized power supply, their signals being processed by induction and anisotropy measuring circuits. Experimental operation of the system has demonstrated that it can be used to analyze variations in magnetic properties, determine the worst end of a roll for subsequent certification testing and determine steps required to optimize technological conditions of the annealing process. References 10: 9 Russian, 1 Western.

UDC 620.179:621.778.079

**Corrosion Resistance of Bright Steel Wire in Diesel Fuel**

*18420075c Moscow STAL in Russian*  
*No 9, Sep 88 pp 73-74*

[Article by L. V. Sechko, N. P. Osheverova, V. Ya. Kiselev, and L. A. Shustova, All-Union Scientific Research Institute of Metal Products]

[Abstract] Two methods were used to determine the corrosion resistance of steel wire in both summer and winter grade diesel fuel with 0.2-0.5 percent sulfur content. High-strength spring steel wire (0.40 and 0.56 mm in diameter) and plates of type 70 steel and electrolytic copper with class 8 surface smoothness were tested. The corrosion activity of winter fuel was found to be higher

than that of summer fuel. 0.40 mm diameter wire showed greater loss of mass than the 0.56 mm diameter wire, though mass loss did not exceed 1 g/m<sup>2</sup>. References 4: all Russian.

UDC 669.14.018.252.3

**Technology for Producing Tungsten-Free High-Speed Steels Types EK41 and EK42**

*18420075d Moscow STAL in Russian*  
*No 9, Sep 88 pp 74-76*

[Article by M. V. Girusova, I. N. Melkumov, and M. A. Lyubinskaya, Elektrostal Plant]

[Abstract] A technology has been developed for producing the new tungsten-free high-speed steels types 9Kh6M3F3AGST (EK41) and 9Kh4M3F2AGST (EK42) suggested to replace high-speed type R6M5 tungsten-molybdenum steel for the working of carbon and medium-alloy structural steels. Specimens from 14 batches of EK41 and EK42 steel were hardened at 1180-1240°C and tempered at 520-560°C. The greatest hardness was that of specimens hardened from 1220-1240°C and triple tempered at 560°C. Grain size increases in steels hardened from 1180°C to 1240°C, and still more if the steel is held even slightly too long before quenching. The steel is now manufactured by melting in an open arc furnace, pouring into 600 and 1000 mm diameter ingots, annealing at 800°C, roughing, forging to 130-140 by 130-140 mm cross section, rolling or forging to 8-130 mm diameter, annealing and adjusting. Hardening and triple tempering yields 62-63 HRC hardness.

UDC 621.762.047:621.77.016

**Cold Rolling of Powdered High-Alloy Iron-Silicon and Iron-Aluminum Alloy**

*18420075e Moscow STAL in Russian*  
*No 9, Sep 88 pp 85-88*

[Article by V. M. Beglov, A. M. Glezer, and N. M. Semenchinskiy]

[Abstract] A study is made of the production of cold-rolled sheet from atomized powders of high-alloy iron-silicon and iron-aluminum melts containing 5-7 percent Si or 15-17 percent Al, obtained by nitrogen atomization. The powders were rolled on a 250 mill in sealed steel containers at 1050-1150°C. The steel shell was then removed and the 7-10 mm sheet hot rolled in air to 2.5-1.0 mm thickness. The mechanical properties of the

rolled sheets were found to be superior to those of cast deformed materials while magnetic characteristics were the same. References 7: 4 Russian, 3 Western (2 in Russian translation).

UDC 621.787:621.3.038.8

**Martensite Transformation in Hardening of Steel by Laser Treatment and Subsequent Deformation**  
*18420055j Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 54-57*

[Article by V. N. Dubnyakov, A. I. Kovalev, and O. L. Kashchuk, Moscow Affiliate of State All-Union Tractor Scientific Research Institute; Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin]

[Abstract] A study is presented of the influence of phase transformations on the mechanical properties of type 45 steel following laser treatment. Laser treatment plus cooling in air caused the formation of two zones in the surface layer—a melted zone (hardened from the liquid state) and a zone of thermal influence (hardened from the solid state) with a transition area toward the center of the material consisting of an austenite-martensite mixture and a ferrite lattice. Mechanical testing revealed phase transformations under the influence of plastic deformation during testing. The appearance of spikes on the tensile testing curve of type 45 steel following laser treatment indicates that martensite conversion occurs during loading. The quantity of martensite formed during deformation is determined by the content of residual austenite, which depends on the initial state of the hardened material. Preliminary hardening increases the strength in the area exposed to laser radiation. References 6: all Russian.

UDC 621.785.5:620.186.4:669.14.018.29

**Influence of Surface Hardening In Stress-Concentration Zones on Tendency of Carbon Steel Toward Brittle Fracture**  
*18420055j Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 49-51*

[Article by V. A. Guryev and Ye. I. Tesker, Volgograd Tractor Plant Production Association]

[Abstract] Studies were performed on standard impact test specimens of type 40 steel with various types of stress concentrators. The specimens were heat treated as follows: a, normalization; b, carburizing plus hardening plus low tempering; c, carbonitriding plus hardening plus low tempering; d, laser treatment. When the material was hardened only in the area of the stress concentrator, the impact toughness of specimens in the -20 to +20°C interval following laser treatment was significantly greater than following carburizing or carbonitriding. The impact toughness of specimens, the side surfaces of which were treated

by the laser, increased significantly throughout the temperature range tested. Treatment of all surfaces also showed the superiority of laser treatment to the more traditional hardening methods. References 2: both Russian.

UDC 669.184:66.012

**Periodic Blowing of Metal in Oxygen Converters by Inert Gas From Above**

*18420054a Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 4 Mar 88) pp 35-38*

[Article by M. I. Volovich, Ye. Ya. Zarbin, R. S. Ayzatulov, V. A. Shcheglov, and O. G. Romanenko, Siberian Metallurgical Institute]

[Abstract] Laboratory studies were conducted involving periodic alteration of the oxidation potential of the blow, decreasing the oxidation of the converter bath by 10-20 percent without decreasing the mean rate of decarburization. Experiments were then continued in a 160 ton converter, replacing the oxygen blown in through the upper level of a two-level tuyere or some of it with neutral gas. Oxygen was blown in at the lower level at 350 m<sup>3</sup>/min and at the upper level at 40-80 m<sup>3</sup>/min. The moment to replace the oxygen with neutral gas and the duration of neutral gas feed were determined by the sound of the blow using an acoustical slag monitoring system, and visually, by the appearance of slag-metal emulsion flowing through the throat of the converter. The laboratory and plant experiments showed that periodic feeding of inert gas through the upper tuyere is an effective means for controlling metal-refining processes and the process of the consumption of the carbon monoxide in the exhaust gases within the converter. References 5: all Russian.

UDC 669.018.95-419.4-122:669.017:620.18

**Structural Changes in Production of Bimetallic Rolled Product With Protective Heat-Resistant Coating**

*18420054c Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 2 Dec 86) pp 75-79*

[Article by B. Ya. Nadvornyy, V. V. Pashinskiy, I. A. Ambaryan, and A. V. Yanshin, Donetsk Polytechnical Institute]

[Abstract] A study is made of the peculiarities of the formation of the structure of a rolled product with a protective coating of chrome-nickel steel produced by a scheme including production of a bilayer blank by casting, followed by rolling. The plastic deformation of rolling significantly influences diffusion processes, changing the direction of motion of the interface between layers. As the degree of deformation is increased to 98.5 percent, mass transfer in the deformation zone does not

decrease the relative thickness of the protective layer, but rather causes it to increase by 14-20 percent. Application of high temperature without plastic deformation increases chemical heterogeneity in the transition zone, primarily due to the ascending diffusion of carbon into the protective coating. The addition of plastic deformation causes the mass transfer process in the deformation zone to become dominant, with mechanical diffusion increasing the relative thickness of the protective layer and reducing heterogeneity in the transition zone. This decreases the decarburized and carburized zones. Bimetallic rolled products of any diameter can be produced by the method with the required combination of technological and service properties, increasing the life of finished products by 3 or 4 times. References 7: all Russian.

UDC 669.15'74'71'28'293-194:620.17/.18

**Influence of Chemical Microheterogeneity on Mechanical Properties of 9G28Yu9MVB Steel**  
*18420054d Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 7 Apr 86) pp 79-83*

[Article by S. A. Bozhko, T. A. Manko, S. I. Krasnikova, and M. G. Vorobyev, Dnepropetrovsk State University]

[Abstract] A study was made of the microheterogeneity of austenite dispersion-hardening 9G28Yu9MVB steel and its influence on the structure and mechanical properties of the metal. Hot rolled bars cooled in air at 1-2°C/min have a clearly banded structure. Aging of the steel at 450-750°C for 1-25 hours causes segregation of hardening-phase particles from the supersaturated solid solution. X-ray spectral microanalysis indicated a different content of alloying elements in the austenite matrix in the different bands. The presence of extended δ-ferrite inclusions in the austenitic matrix was found to be a major reason for the great anisotropy of mechanical properties of the steel. Heating to 1150°C with subsequent holding reduces anisotropy, yielding almost complete δ to γ conversion. Homogenizing treatment or hot deformation can eliminate the δ ferrite, though the microheterogeneity of alloying element distribution remains significant. Elimination of the δ ferrite significantly improves ductility and toughness, particularly across the fibers. References 3: 2 Russian, 1 Western.

UDC 669.15'24'26'28'74'782-194:621.785.78

**Influence of Heating After Deformation on Aging and Recrystallization of Austenitic Steel**  
*18420054e Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 8, Aug 88 (manuscript received 12 Feb 86) pp 83-85*

[Article by V. R. Baraz, A. A. Pereboyeva, T. A. Orelkina, and G. I. Valavina, Krasnoyarsk Institute of Non-ferrous Metals]

[Abstract] A study is made of the influence of heating on processes occurring in type 13Kh18N10G3S2M2 steel

after hardening with subsequent deformation. The kinetics of decomposition and recrystallization processes were studied on strip specimens with respect to change in strength and by x-ray structural methods with respect to expansion of the (311) line of the austenite. A significant increase in strength was observed due to recovery and deformation aging after even 30 seconds holding at 500, 600 or 700°C. Aging of hardened specimens leaves the width of the (311) line virtually unchanged. Heating of deformed specimens to 600°C results in a decrease in the width of the line in less than 30 minutes of holding. Further increases in aging time do not cause significant changes in β for 40 and 55 percent deformation. In steel deformed by 70 percent, holding over 16 hours causes another decrease in the width of line (311), related to the initial formation of a recrystallization structure. References 6: all Russian.

UDC 669.14.018.252.3:660.772'781:620.191.32

**Effect of Silicon and Boron on Scaling Resistance of High-Speed Tool Steels**

*18420032a Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8, Aug 88 pp 2-6*

[Article by A. I. Aparova, L. A. Alekseyev, and A. I. Lyapunov, All-Union Scientific Research Institute of Tool Design (VNII instrument)]

[Abstract] An experimental high-temperature oxidation study of high-speed tool steels has confirmed the feasibility of increasing their resistance by addition of silicon or boron rather than aluminum as in the American practice. Specimens of eight tool steels (R-2Mo5, R-6Mo5, R-6Mo5Co5, R-6N<sub>2</sub>Mo5V3, R-9Mo4Co8, R-9Co5, R-18, R-3Mo3V2NbTiSi) and three other alloy steels (11Mo5VALN<sub>2</sub>Si, 9Cr6Mo3V3N<sub>2</sub>MnSiTi, 9Cr6Mo3V2N<sub>2</sub>MnSiTi) were tested, three 100 mm wide and 20 mm long specimens of each, at a temperature of 1150 deg C for 3 h. Measurements by the loss-of-mass method revealed a parabolic rather than linear scaling process, the resistance of 11Mo5VALN<sub>2</sub>Si steel with zero tungsten content being the highest and that of R-2Mo5 steel following next. The resistance to high-temperature oxidation was found to decrease with increasing tungsten content. An attempt is made to interpret the results in terms of metal-oxygen bond strength proportional to the square of the difference between their electronegative potentials. Alloying the steels additionally with Si or B did not alter their relative ranks with respect to scaling resistance. In an optimization experiment with another tool steel (R-3Mo3V2) minimum scaling rates were obtained with 1.6 pct Si and with 0.005 pct B, a higher content of either element again accelerating the high-temperature oxidation. Phase analysis by the method of nuclear-magnetic-resonance spectroscopy in a YaGRS-4 spectrometer with a <sup>57</sup>Co (Cr) source revealed the presence of fayalite and fine-disperse X-radiographically

amorphous super-paramagnetic oxides as principal components of the scale, quantitative changes in hematite and magnetite content not having a significant effect on the oxidation rate. References 5: 4 Russian, 1 Western.

UDC 669.14.018.252.3

### Tungstenless High-Speed Tool Steels

**12Mo5V3SiAl and 11 Mo3V3SiNbZr**

*18420032b Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 8, Aug 88 pp 6-8*

[Article by V. P. Alferov, L. A. Kochkina, G. B. Layevskiy, and G. Yu. Novikova, Kirovskiy Zavod Production Association]

[Abstract] Two experimental tungstenless (0.46-0.68 pct W) high-speed tool steels were delivered to the Kirov Plant by the Izhestal Production Association, 12Mo5V3SiAl containing 0.30-0.90 pct Al (0.65-0.82 Si) from four blows and 12Mo5V3SiNbZr containing 0.030 pct Nb plus 0.01 pct Zr (0.50 pct Si) from one blow, for a determination of the optimum heat treatment and of their suitability as replacements of R-6Mo5 or R-6N<sub>2</sub>Mo5V3 standard steels containing tungsten. Rods of both steels 30 mm and 40 mm in diameter were quenched from temperatures of 1160-1200 deg C in 10 deg C steps, after soaking for 2 min plus 5 s per mm thickness at each temperature, and then tempered three times at 350 deg C, 570 deg C, 550 deg C successively for 1 h at each temperature. The results of hardness measurements upon delivery and after additional tempering at 620 deg C for 4 h indicate a lower red hardness at temperatures below the flashing point and no advantage of 350-570-550 deg C tempering over conventional 560 deg C tempering. The results of mechanical tests for tensile strength, impact strength (10x10 mm<sup>2</sup> bars 60 mm long without notch), and deflection in bending (6x6 mm<sup>2</sup> bars 60 mm long) indicate excellent characteristic independent of the quenching temperature within the 1170-1190 deg C range. Metallographic examination and cutting tests show that neither steel is equivalent to R-6Mo5 steel.

UDC 669.14.018.298:620.17:620.18

### Martensitic-Austenitic Steels as Effective Structural and Tool Materials

*18420032c Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 8, Aug 88 pp 9-12*

[Article by V. G. Gorbach, I. V. Sidoruk, and Ye. A. Izmaylov; Kiev Polytechnic Institute, and Kirgiz State University]

[Abstract] Five martensitic-austenitic steels (Ni26AlTi2Nb, Ni21Mo2Ti2Nb, O3Ni18Mo2Ti2, O3Cr13Ni10Ti2, O3Cr11Ni 10Mo2Ti2) are evaluated for use as structural and tool materials relative to

45CrNiMoVN<sub>2</sub> plain martensitic high-strength steel not containing residual austenite. Their mechanical characteristics are compared after heat treatment by quenching from 850-950 deg C, subsequent cold treatment at -70(-196) deg C for maximum martensitization, and final aging at a temperature within the alpha-to-gamma transformation range (520-540 deg C depending on the steel) for 1 h. The data indicate an extraordinary combination of mechanical characteristics, high strength and plasticity as well as modulus of elasticity and also coercive force, making these steels eminently suitable for casting molds and gear cutters. References 9: all Russian.

UDC 620.17:620.186.1:669.14.018.254

### Effect of Metastable Residual Austenite on Mechanical Characteristics of Cr12Mo Steel

*18420032d Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 8, Aug 88 pp 12-15*

[Article by L. S. Malinov, A. P. Cheylyakh, and O. D. Cheylyakh; Zhdanov Metallurgical Institute, Zhdanovtyazhmash Production Association Planning Department]

[Abstract] An experimental study of Cr12Mo martensitic structural steel was made for the purpose of determining the dependence of its mechanical characteristics on the concentration of residual austenite. That concentration was varied by changing the heat treatment and was estimated on the basis of subsequent magnetic measurements. Mechanical testing was done by "soft" loading, in torsion, which made it possible to monitor the martensitic transformation directly. Specimens of this steel were quenched from temperatures of 1000-1200 deg C and then tempered at temperatures of 200-600 deg C, austenite becoming destabilized most likely within the 400-600 deg C range and during subsequent cooling. Maximum ultimate strength and thus maximum increase of martensite content were attained by tempering at 500 deg C, the yield strength dipping to a minimum after tempering at 400 deg C and then gradually increasing after tempering at successively higher temperatures. References 13: all Russian.

UDC 669.14.018.298:620.17

### Structural Soundness of Low-Carbon Rotor Steel

*18420032e Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 8, Aug 88 pp 16-18*

[Article by V. I. Voropayev, O. V. Filimonova, and I. A. Borisov]

[Abstract] New rotor steels more suitable than those of the 25CrNi3MoVN<sub>2</sub> class for structural components of large electric generators are being developed by the Central Scientific Research Institute for Machine-Building Technology Scientific-Production Association,

the object being to reduce the carbon content and to increase the nickel content so as to improve both the hardenability and the ductility of large sections. Ingots weighing 500 kg taken from five different ladles (0.14-0.16 pct C, 4.2-4.5 pct Ni, 1.0-1.6 pct Cr, 0.48-0.66 pct Mn, 0.48-0.60 pct Mo, 0.09-0.10 pct V, 0.005-0.01 pct S, 0.001-0.005 pct P) were studied for the dependence of their mechanical characteristics on the heat treatment and for the effect of alloying with Nb or Co. The heat treatment of 95 mm thick 200x200 mm<sup>2</sup> large plates and 180 mm long 16x16 mm<sup>2</sup> large bars cut from those ingots consisted of austenitization and holding for 2 h at 850 deg C, four different modes of cooling (1. at 50 K/h in furnace, 2. at 25 deg/min in air, 3. at 2.8 deg/s in oil, 4. at 28 deg/s in water), tempering at 630 deg C for 40 h, and cooling in furnace (to 530 deg C at 50 deg/h, then faster). Standard test specimens cut out after heat treatment with cooling at 50 deg/h were again heated to, and held for 5 h at, 600 deg C, then cooled in water, so as to prevent temper brittleness of the second kind. Static tensile and impact tests as well as fatigue tests under low-frequency (6 Hz) asymmetrically (10 pct) alternating cyclic loads were performed, the results indicating that heat treatment with fast cooling at up to 28 deg/s yields the best combination of mechanical characteristics with a high resistance to embrittlement. Addition of 0.01-0.08 pct Nb was found to enhance these characteristics, while addition of 2.0-3.0 pct Co was found to raise the 50 pct embrittlement temperature and stress intensity during cracking. References 3: all Russian.

UDC 669.14.018.256:620.17:620.181

#### Effect of Chromium on Structure and Properties of 35MnSiVNb Steel for Turbodrill Shafts

18420032f Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 8, Aug 88 pp 18-21

[Article by R. I. Shukyurov, V. N. Zikeyev, V. A. Ismaylov, and V. I. Sulatskov]

[Abstract] An experimental study of 35MnSiVNb steel for turbodrill shafts and bits was made for a determination of the optimum Cr content necessary to ensure reliable performance, Cr being necessary as carbide-forming element in addition to the V and Nb microcontent. Ingots weighing 17 kg taken from four different ladles (0.34-0.35 pct C, 0.92-0.98 pct Mn, 0.53-0.55 pct Si, 0.08-0.09 pct V, 0.05-0.06 pct Nb, and 1.9, 2.5, 2.9, and 3.4 pct Cr respectively) were forged into bars 14x14 mm<sup>2</sup> in cross section and into rods 30 mm in diameter. The heat treatment consisted of quenching in oil from 880 deg C after soaking for 30 min at that temperature and then tempering at temperatures of 600-700 deg C for 1.5 h at each temperature with subsequent cooling in water. Addition of Cr was found to soften the dependence of strength and plasticity on the tempering temperature by increasing both tensile and torsional strength as well as the hardness while decreasing the plasticity throughout the range, to also increase the impact

strength but to shift the optimum tempering temperature upward and to lower the 50 pct embrittlement temperature. According to the test data, 2.5-2.9 pct Cr is the optimum range for best tradeoff of mechanical characteristics and for lowest 50 pct embrittlement temperature: -44 deg C with 2.5 pct Cr and -41 deg C with 2.9 pct Cr. References 8: all Russian.

UDC 669.14.018.298:620.178.2

#### Proneness of Cr-Ni-Mo Steel to Thermal Embrittlement

18420032g Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 8, Aug 88 pp 21-23

[Article by V. M. Goritskiy, G. V. Shneyderov, and V. I. Bogdanov, TsNII proyektstal'konstruktziya]

[Abstract] An experimental study of normalized O8Cr4Ni2Mo martensitic plate steel (0.11 pct C, 3.9 pct Cr, 2.0 pct Ni, 0.43 pct Mo, 0.38 pct Mn, 0.29 pct Cu, 0.29 pct Si, 0.028 pct P, 0.011 pct S, 0.032 pct N<sub>2</sub>) was made for the purpose of determining its proneness to thermal embrittlement. The heat treatment of 30 mm thick plate consisted of quenching in water from 900-920 deg C after soaking for 30 min at the given temperature within this range and then tempering at 650 deg C for 1.5 h with subsequent cooling in air. After this 60 mm wide and 100 mm long specimens were held in a muffle furnace at 340, 400, and 450 deg C for 100-2500 h at each temperature. They were then tested for flexure under impact at temperatures from -40 deg C to 120 deg C. Foils produced by electrolytical slicing with a mixture of 85 ml H<sub>3</sub>PO<sub>4</sub> and 15 g CrO<sub>3</sub>, also carbon replicas, were examined under a Tesla BS-540 electron microscope for transcrystalline and intercrystalline fractures. The results revealed an appreciable rise of the 50 pct embrittlement temperature after aging at successively higher temperatures (15-55-75 deg C higher after aging at 340-400-450 deg C for 1000 h) without an increase of intercrystalline fracture beyond 46-51.2 pct of total fracture, indicating reversible temper brittleness. Brittle intercrystalline cracking evidently proceeds along boundaries of former austenite grains, leaving intercrystalline and transcrystalline facets with equal dimension and form factors. According to comparative data, this steel has a higher resistance to thermal embrittlement than the martensitic-bainitic tempered 10CrSiNiCu steel. References 5: all Russian.

UDC 620.193.2:669.15'26-194

#### Corrosion and Cavitation-Corrosion Resistance of 95Cr18 Steel

18420032h Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 8, Aug 88 pp 56-61

[Article by V. V. Berezovskaya and Yu. G. Veksler, Ural Polytechnical Institute]

[Abstract] An experimental corrosion and cavitation study of 95Cr18 steel (0.92 pct C, 18.3 pct Cr, 0.63 pct Mn, 0.12 pct Ni, 0.79 pct Si, 0.025 pct P, 0.023 pct S)

was made, this steel having been quenched in oil from 1000-1200 deg C after soaking for 30 min and then tempered at 200 deg C for 2 h for stress relieving. Specimens were tested in 0.5M H<sub>2</sub>SO<sub>4</sub> and 5M H<sub>3</sub>PO<sub>4</sub> solutions, their corrosion resistance being determined on the basis of the current density within the passivation range of potentiostatic polarization curves. Cavitation was produced by agitating the medium with an ultrasonic oscillator. Subsequent structural examination including fractography was done under a Reichert optical microscope and under a Stereoscan-180 scanning electron microscope. Phase analysis was done in a URS-50IM x-ray diffractometer and with a Steinberg-Sousin magnetometer. The results are compared with available analogous data on 12Cr18Ni9Ti steel. They indicate that corrosion of 95Cr18 steel under static conditions occurs by active dissolution of the martensite and that its otherwise deep passivation becomes destabilized by cavitation. References 8: 4 Russian, 4 Western (1 in Russian translation).

UDC 669.18.046.553

#### Formation of Phases During Deoxidation of Steel by Silicon and Aluminum

18420034a Moscow *IZVESTIYA AKADEMII NAUK*  
SSR: *METALLY* in Russian No 4, Jul-Aug 88  
(manuscript received 27 Apr 87) pp 10-16

[Article by G. G. Mikhaylov, Ye. M. Vilgelm, L. A. Chernova, and O. K. Tokovoy, Chelyabinsk]

[Abstract] Formation of nonmetallic phases during deoxidation of steel by silicon and aluminum is described as involving nine chemical reactions with corresponding inversely temperature dependent thermodynamic equilibrium constants. Quantitative analysis covers four systems: FeO-SiO<sub>2</sub>, SiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub>, FeO-Al<sub>2</sub>O<sub>3</sub>, and FeO-SiO<sub>2</sub>-Al<sub>2</sub>O<sub>3</sub>. Available data are used for calculating the activity of each component in the slag melt and the solubility of each component in the liquid metal at equilibrium with the given oxide. The results indicate that deoxidation by both silicon and aluminum together is possible when the metal originally contains more than 0.1 pct O<sub>2</sub> or when the Si concentration exceeds 1 pct, oxygen combining principally with aluminum. References 8: 6 Russian, 2 Western.

UDC 669.18.046.518:621.746.047

#### Optimum Conditions for Solidification of Continuous Horizontal Castings

18420034b Moscow *IZVESTIYA AKADEMII NAUK*  
SSR: *METALLY* in Russian No 4, Jul-Aug 88  
(manuscript received 24 Dec 86) pp 72-81

[Article by V. V. Sobolev and P. M. Trefilov, Krasnoyarsk]

[Abstract] Solidification of a metal from its melt is analyzed for continuous horizontal casting on the basis of equations describing the attendant thermophysical processes and the resultant temperature field kinetics. Heat

transfer within the liquid-solid zone is treated according to the theory of quasi-equilibrium in a two-phase system, disregarding as negligible stratification of the metal caused by heat convection. The optimum conditions in terms of moving and stopping time as well as velocity pulseform are established for solidification of such castings with respect to seven integral functionals serving as criteria, five of them characterizing changes within the liquid pool, one characterizing thermal stresses in the solid skin, and one characterizing specifics of this casting technology. The results are applied to the production of rectangular steel castings by this continuous process. References 11: all Russian.

UDC 669.046

#### Effect of Gravity Coalescence on Yield of Metal Suitable for Casting

18420034c Moscow *IZVESTIYA AKADEMII NAUK*  
SSR: *METALLY* in Russian No 4, Jul-Aug 88  
(manuscript received 17 Mar 87) pp 82-84

[Article by I. N. Kashcheyev, V. P. Tupitsyn, and I. A. Mirkin (deceased), Moscow]

[Abstract] Gravity coalescence of molten metal is analyzed theoretically on the basis of the equation of drop growth kinetics in accordance with Stokes' law, this process being the only one which ensures manageable velocity of metal flow. Calculations are made for a bidisperse mixture of drops, the larger ones absorbing the smaller ones on the way down and eventually filling an inverted right conical frustum. An expression is obtained on this basis for the metal yield factor characterizing the fraction of continuous liquid formed by successive n first drops. This expression and numerical estimates are extended to a polydisperse mixture of drops shown to be more efficacious in forming continuous liquid metal. References 3: all Russian.

UDC 621.771.764

#### Kinematics of Planetary Strip Rolling

18420034d Moscow *IZVESTIYA AKADEMII NAUK*  
SSR: *METALLY* in Russian No 4, Jul-Aug 88  
(manuscript received 5 Jan 87) pp 85-88

[Article by A. N. Skornyakov, Moscow]

[Abstract] Planetary strip rolling with two pairs of rolls is analyzed from the standpoint of kinematics, the key parameters of this process being the rolling radius and the longitudinal velocity of metal flow. The analysis is based on universal geometrical relations applicable to all such rolls, even though the magnitudes of the characteristics angles vary depending on the design of the roll ensemble. It reveals that such rolling always advances the metal by forward slip and, in the case of small angles of the neutral surface, in accordance with Dresden's law. The circumferential velocity of the separators remains constant where rolling occurs with overlap, but builds up where only one

pair of rolls is active while their velocity and that of the support rolls remains constant. References 5: all Russian.

UDC 620.164.1.002-413

### Effect of Forming Process on Mechanical Characteristics of Thick Plates

18420034e Moscow IZVESTIYA AKADEMII NAUK  
SSR: METALLY in Russian No 4, Jul-Aug 88  
(manuscript received 21 Nov 86) pp 98-101

[Article by A. V. Pronyakin, V. F. Kashirin, S. A. Gladyshev, and A. V. Zinov'yev, Moscow]

[Abstract] Hot rolling of ingots into thick plates is analyzed theoretically for its effect on the mechanical characteristics of the material, considering that this process produces a plane state of strain describable by a strain tensor which takes into account macroshear in the direction of rolling and anisotropic changes in the mechanical properties. While strength and plasticity as well as ductility increase in the plane of rolling after successive passes, to different levels longitudinally and transversely, normally to the plane of rolling, they do not change appreciably but peak slightly after only a few passes and then again decrease. The results of this analysis including geometrical factors, namely width of asperities and recesses as well as of bevels, are applied to hot rolling the V95 Al-Zn-Mg alloy with a shear angle of 48-55 deg at 450-400 deg C. Calculations for a typical 50 mm thick ingot 100 mm wide and 200 mm long indicate the feasibility of producing 3 mm thick plates in up to 8 passes in a mill with two cages. References 3: all Russian.

UDC 669.15'24'26'28'74-194

### Dependence of Phase Composition of Cast CrMnNiMoV Steel on Carbon Content and Austenitization Temperature

18420034i Moscow IZVESTIYA AKADEMII NAUK  
SSR: METALLY in Russian No 4, Jul-Aug 88  
(manuscript received 18 Nov 86) pp 127-131

[Article by B. B. Vinokur, S. Ye. Kondratyuk, O. G. Kasatkin, and R. A. Khrunik, Kiev]

[Abstract] An experimental study of cast hypereutectic CrMnNiMoV steel with variable 0.69-1.12 pct C content and fixed 1.32 pct Cr, 1.30 pct Mn, 0.82 pct Ni, 0.25 pct Mo, and 0.1 pct V content was made for the purpose of determining the dependence of its phase composition on the carbon content and the austenitization temperature. The carbon content was varied by fractional pouring of the melt. Ingots with 0.69, 0.81, 0.92, 0.98, and 1.12 pct C were quenched from temperatures of 725, 750, 775, 800, 825, 850 deg C, the critical points for each carbon content being determined dilatometrically. Quantitative determinations of martensite, residual austenite, and carbides were made on the basis of metallographic and x-ray structural examinations, magnetic measurements, and chemical phase analysis. Evaluation of the data by regression analysis reveals

that the dissolution of carbides before quenching depends not only on the temperature itself but also on its position relative to the  $Ac_1$  and  $Ac_{cm}$  temperatures. Both the ratio of martensite to residual austenite and the alloying level in the steel depend not only on the carbon content and the austenitization temperature but also on the concentration of undissolved carbides as a third determining factor. References 4: all Russian.

UDC 669.14.018.252.3

### Solubility of Vanadium Carbides in Austenite of Tungstenless Low-Alloy High-Speed Tool Steels

18420034j Moscow IZVESTIYA AKADEMII NAUK  
SSR: METALLY in Russian No 4, Jul-Aug 88  
(manuscript received 16 Mar 87) pp 132-133

[Article by A. N. Papandopulo, Ko Men Chkhor, and N. B. Tsvetova, Leningrad]

[Abstract] The phase composition of two tungstenless high-speed tool steels, O9Cr6Mo3V3 and O9Mo3V2, was studied by the method of direct x-ray spectral micro-analysis, differentiation between primary and secondary carbides being possible by this method but not on the basis of comprehensive physical and chemical analysis. Specimens of both steels cut from hot forged and annealed bars 6x6 mm<sup>2</sup> in cross-section were examined in a DRON-2 x-ray diffractometer and under an MMR-2 metallographical microscope before and after heat treatment consisting of austenitization at temperatures of 1160, 1200, 1240 deg C for 3 min in a BaCl<sub>2</sub> bath with subsequent cooling to 500 deg C in a NaOH melt and then to room temperature in air. These examinations were aided by a CAMEBAX-MICRO analyser with a KEVEX video monitor and a dispersion energy-spectrometer, quantitative evaluation of the data being aided by a minicomputer with an RDR11-03 microprocessor. They revealed  $Me_6C$ ,  $MeC$ ,  $Me_7C_3$ ,  $Me_3C$  carbides in the steels after annealing and  $MeC(VC)$  as principal carbide after quenching. The secondary VC was found to contain 15-20 atom.pct less V and more, up to 20 atom.pct, dissolved Fe than the primary VC with approximately the same Mo and Cr impurity content in both. In the O9Cr6Mo3V3 steel the V content in its carbides was found to decrease as the austenitization temperature was raised, owing to dissolution of VC, with the Mo content increasing but the Fe content remaining constant in the primary VC and decreasing in the secondary VC. In the O9Mo3V2 steel hardly any VC was dissolved throughout the range of austenitization temperatures, the austenite having evidently been saturated with  $Me_7C_3$  and  $Me_6C$  carbides. References 9: all Russian.

UDC 669.14.018.291.3:620.186

### Structural State of Concrete-Reinforcing Steel Hardened by Heat Treatment in Rolling or by Separate Heat Treatment

18420034k Moscow IZVESTIYA AKADEMII NAUK  
SSR: METALLY in Russian No 4, Jul-Aug 88  
(manuscript received 10 Mar 87) pp 146-148

[Article by V. V. Kalmykov and Ye. N. Shilovskaya, Dnepropetrovsk]

[Abstract] An experimental study of 20MnSi concrete-reinforcing steel (0.19 pct C, 1.32 pct Mn, 1.08 pct Si,

0.022 pct S, 0.021 pct P) quenched from 950 deg C was made for the purpose of comparing its structural states after hardening in the process of hot rolling as done at the Krivorozhstal Combine and after similar but separate hardening in a furnace respectively. Hardening was in each case followed by tempering at various temperatures over the 300-600 deg C range for 1 h with subsequent cooling in air. Mechanical tests revealed no significant differences after tempering at 300 deg C, but after tempering at 400-600 deg C the steel hardened in rolling was found to have a higher yield point than the steel hardened separately. Microstructural examination under an EMMA electron microscope revealed precipitation of carbon in the form of carbides along boundaries of martensite grains, formation of carbides being more intense and accompanied by fragmentation of those grains but their precipitation density being lower in the rolled steel than in the separately hardened one. This difference in the mode of restructurization was found to become more pronounced with higher tempering temperature. References 6: 4 Russian, 2 Western (both in Russian translation).

UDC 669.15-194.57:621.785.783

**Characteristics of Natural Aging of Ferritic Stainless Steels Stabilized With Titanium**  
*184200341 Moscow IZVESTIYA AKADEMII NAUK SSR: METALLY in Russian No 4, Jul-Aug 88 (manuscript received 26 Feb 87) pp 149-154*

[Article by A. N. Babitskaya and A. L. Bondarenko, Zaporozhye]

[Abstract] An experimental study of two ferritic stainless steels O8Cr18Ti1 (0.07 pct C, 17.75 pct Cr, 0.71 pct Ti, 0.70 pct Si, 0.32 pct Mn, 0.25 pct Ni, 0.10 pct Cu, 0.026 pct P, 0.009 pct S) and O8Cr16TiMo (0.08 pct C, 15.5 pct Cr, 0.98 pct Ti, 0.44 pct Mo, 0.37 pct Si, 0.33 pct Mn, 0.15 pct Ni, 0.10 pct Cu, 0.018 pct P, 0.009 pct S) was made concerning their natural aging, specimens of 0.8 mm and 1.0 mm thick cold-rolled sheet having been first recrystallized in a continuous furnace and some of them subsequently etched. The recrystallization heat treatment of sheet rolling at a velocity of 7.5-8.0 m/min consisted of heating it at the exit from the last cage to 940-960 deg C, holding for 2.5-3.0 min, and cooling with a water shower. Etching was done in 40-50 s with a caustic melt at a temperature of 450-530 deg C. Some sheet specimens had been, prior to cold rolling, hot rolled under laboratory conditions with a stabilizing heat treatment (heating to 950 deg C - holding for 30 min - cooling in air) for more complete precipitation of carbon and nitrogen from the solid solution in the form of TiC and TiN. Cold rolling of 1.0 mm thick sheet was followed by heating it to 950 deg C, holding for 3 min, and cooling in air. Subsequent study included microstructural examination under a UEMV-100A electron microscope using carbon replicas, phase analysis in a DRON-1 x-ray diffractometer with a  $\text{CuK}_{\alpha}$ -radiation source and a monochromator, microhardness measurement with a PMT-3 tester under a 0.2 N load, and an Erichsen ductility-cupping test with an MTL10G

instrument. The results reveal an overaging effect after 1 month, namely formation of solitary secondary  $\text{Fe}_3\text{N}$  and CrN as well as  $\text{Fe}_2(\text{N},\text{C})$  and  $\text{Cr}(\text{N},\text{C})$  precipitates with attendant decrease of the microhardness from its maximum 2200-2500 Rockwell B to a stable 1800-1900 Rockwell B. Stabilizing heat treatment of sheet hot rolled prior to its cold rolling was found to suppress dispersion hardening of both steels by stimulating precipitation of TiC and TiN, the sheet then retaining its hardness for 2 months when heat treated for recrystallization and then fast cooled after cold rolling. References 7: 6 Russian, 1 Western (in Russian translation).

UDC 621.07.011:539.67

**Internal Friction in High-Speed Tool Steels After Hydromechanical Pressure Treatment and Heat Treatment**

*18420034n Moscow IZVESTIYA AKADEMII NAUK SSR: METALLY in Russian No 4, Jul-Aug 88 (manuscript received 3 Mar 87) pp 159-164*

[Article by V. A. Beloshenko, O. I. Datsko, A. A. Lyadskaya, V. Z. Spuskanyuk, and A. D. Shakhova, Donetsk]

[Abstract] An experimental study of three high-speed tool steels was made concerning their restructurization under hydromechanical pressure treatment and subsequent heat treatment. Rods of cast R-6Mo5 and 1OR-6Mo5Co5 steels were produced by hot rolling. Rods of 1OR-6Mo5 and 1OR-6Mo5Co5 powder steels were produced by hot extrusion in a shell. All rods were first compressed hydraulically, whereupon rods of each kind with percentage deformation ranging from 13 to 51 were heat treated by tempering at various temperatures over the 200-750 deg C range for 30 min, quenching from 1200 deg C, and then tempering again but now 3 times at 530 deg C for 30 min. Restructurization in the entire process was monitored indirectly by subsequent measurement of internal friction with an "inverted torsional pendulum" at temperatures up to 900 deg C during heating of the rods at a rate of 2.5 deg/min, as well as by metallographical examination and microhardness measurement. Measurement of internal friction has revealed that the critical strain amplitude increases with increasing percentage deformation prior to heat treatment. The results of this study indicate ways to optimize the heat treatment of high-speed tool steels after they had been mechanically deformed. References 14: all Russian.

UDC 620.178.162

**Abrasive Wear Resistance of Carbon Steel After Electric Spark Alloying**

*18420049e Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 27 Nov 87) pp 101-103*

[Article by V. M. Golubets, V. V. Kozub, and M. I. Pashechko, Physical Mechanical Institute imeni G. V. Karpenko, Ukrainian Academy of Sciences, Lvov]

[Abstract] A study was made of the influence of electric-spark alloying using an electrode of an eutectic Fe-Mn-B-C alloy on the friction and wear of type 45 steel in

an abrasive medium. Machining time was selected at the rate of one square centimeter per minute. The wear resistance of hardened and surface treated specimens was significantly greater than that of normalized and electric-spark alloyed surfaces. As the hardness of the base metal increases, wear resistance rises as well. The greatest wear resistance is that of friction couples hardened by electric-spark alloying at  $420 \mu\text{F}$  and 1 A, yielding a coating  $35 \mu\text{m}$  thick, then hardened and tempered. The studies indicate that the eutectic alloy used is suitable for manufacture of electrodes for electric spark hardening of parts, increasing the wear resistance of type 45 carbon steel by a factor of 2-4 in comparison to hardened but not spark treated steel. References 4: all Russian.

UDC 621.789.2:678.026

#### Increase in Wear Resistance of Iron and Titanium Alloys Strengthened by Electrourasonic Treatment

18420049f Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 14 Jul 87) pp 103-106

[Article by Yu. I. Babey, O. A. Makar, and V. A. Chervatyuk, Physical Mechanical Institute imeni G. V. Karpenko, Ukrainian Academy of Sciences, Lvov]

[Abstract] Electrourasonic treatment consists of ultrasonic treatment of a metal surface with transmission of an electric direct current from the cathode tool to the anode part. The point arc power source, with a density of at least  $10^8 \text{ W/m}^2$ , melts a local area of the part, and the bath of the melt, reacting with the surrounding atmosphere, is saturated with nitrogen and oxygen from the air. It has been established that saturation of the metal with these elements results in the formation of nitrides and oxides, producing a continuous layer of very high hardness on the surface of the metal. Electrourasonic hardening of a specimen 40 mm in diameter was performed at a rotating speed of  $6.25 \text{ s}^{-1}$ , a longitudinal feed rate of  $0.08 \text{ mm/rev}$  and oscillation amplitude of  $10 \mu\text{m}$

without load. The microhardness and thickness of the layer produced on type 40 steel was found to be lower than on titanium. The structure of the layer produced was continuous, and the microhardness of both steel and titanium increased with increasing total specific power of the treatment. The increase in wear resistance is not as great in dry friction as in a medium of oil containing abrasives. Electrourasonic treatment can produce a surface film for retention of polymer coatings to decrease wear in dry friction. After application of the polymer, the hardened metal was covered with a mixture of polymer and copper particles. The projecting sections of the hardened matrix receive the contact loads, the metal-polymer mixture lubricating the friction couple. The advantages of this combined treatment include the fact that the polymer composition prevents wear of inserts and improves the microgeometry of the hardened surface, thus increasing the wear resistance of friction couples. References 8: all Russian.

UDC 539.56:669.788

#### Specifics of Hydrogen Embrittlement of 06KhGR and 38KhA Steels

18420049i Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 17 Mar 87) pp 121-123

[Article by N. K. Kondakova, M. A. Leytes, Ye. N. Zhukova, and T. K. Sergeyeva, Central Ferrous Metallurgy Scientific Research Institute imeni I. P. Bardin, Moscow]

[Abstract] A study is made of the hydrogen embrittlement of two-phase type 06KhGR steel in comparison with type 38KhA ferritic-pearlitic steel traditionally used for the manufacture of fasteners. Hydrogen embrittlement was studied by electrolytic hydrogenation of specimens in 0.1 n sulfuric acid with 1.5 g/l thiourea at a current density of  $500 \text{ A/m}^2$ . All specimens of 06KhGR steel were found to have superior durability to type 38KhA steel. Maximum strength was seen in laboratory 06KhGR steel with high silicon content, heat treated immediately after hot rolling. References 3: all Russian.

UDC 666.762.93:621.315.61

**Boron Nitride Ceramic Materials**

*18420109 Moscow OGNEUPORY in Russian  
No 12, Dec 88 pp 13-15*

[Article by L. N. Rusanova]

[Abstract] In the past few years, a number of boron nitride-based materials have been developed with advantages over pyrolytic and hot-pressed materials not only in terms of their properties, but also in terms of ease of manufacture. These materials are manufactured by molding in steel press molds or hydrodynamic machines and sintering. Pure isotropic materials with satisfactory strength over a broad temperature range have been obtained by producing materials of powders containing amorphous boron molded at room temperature and sintered in nitrogen at 1300-1500°C. Ceramics have been produced from graphite-like boron nitride by sintering individual particles of the powder with active pyrolysis products formed in the process of destruction of heteroorganic compounds in the charge during heat treatment, in a process called molecular thermal cross-linking. The simplicity and cheapness of the technology make it suitable for mass production of boron nitride products for many areas of use. References 7: 6 Russian, 1 Western.

UDC 621.7.044.2

**Effectiveness of Preliminary Oxidation in Manufacture of Titanium-Copper Bimetal**

*18420102 Minsk DOKLADY AKADEMII NAUK BSSR in Russian Vol 32 No 11, Nov 88 (manuscript received 14 Dec 87) pp 1001-1004*

[Article by V. I. Belyayev, F. N. Borovik, and A. S. Masakovskaya, Belorussian Polytechnical Institute]

[Abstract] The physical picture of the formation of joints in solid-state welding based on self-consistent computation of the energy spectra is described. The Hartree-Fock-Slater equations are used, in contrast to earlier works which used the Thomas-Fermi model, a quasiclassical approximation of the Hartree-Fock-Slater equations. It was found that preliminary oxidation of the titanium surface was an effective means to control mass transfer of the titanium, the phase composition of inclusions, the quantity of intermetallides and thus to improve the strength of the composite material. References 5: 1 Russian, 4 Western.

UDC 621.762.222

**Vibration Installation for Production of Titanium Carbide Powders**

*18420097c Dnepropetrovsk METALLURGICHESKAYA I GORNORUDNAYA PROMYSHLENNOST: NAUCHNO-TEKHNICHESKIY I PROIZVODSTVENNYY SBORNIK in Russian No 4, Oct-Dec 88 pp 49-50*

[Article by I. A. Shulyak, A. P. Archakov, and V. A. Petrenko, IGTM; Transcarpathian Mercury Combine]

[Abstract] A description is presented of a vibration installation used to crush and classify titanium carbide

powder at the authors' plant. Experimental studies were performed to determine the technological characteristics of the vibration grinding process. The best results were obtained using balls 32mm in diameter, which are big enough to crush large particles and have sufficient kinetic energy to achieve the 80 percent increase in fine classes of crushed material desired. The vibration equipment can be used to set up a highly productive technological line for production of powders of titanium carbide and other brittle, abrasive materials. References 2: both Russian.

UDC 669.184:658.386

**Oxygen Converter Operator Trainer**

*18420089 Moscow IZVESTIYA VYSSHikh UCHEBNYkh ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 10, Oct 88 (manuscript received 11 Apr 88) pp 136-139*

[Article by S. P. Mochalov, V. P. Tsymbal, S. A. Shipilov, S. V. Klemashev, V. M. Tolstenev, and A. G. Padalko, Siberian Metallurgical Institute]

[Abstract] An analysis is made of the problems of developing a functional-technical trainer for oxygen converter operators. An experimental model of such a trainer was introduced at the authors' institute in 1981. A flow chart of the trainer is presented. The device includes an operator's control panel designed to be as similar as possible to the panel on an actual oxygen converter. A process noise imitator is even included, modeling the noise of an operating oxygen converter. The trainer adequately reproduces the situation at the working location of an oxygen converter operator. References 6: all Russian.

UDC 669.295:539.4.015

**Dislocation Substructure and Mechanical Properties of Titanium Deformed at Different Speeds**

*18420099c Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 66 No 4, Oct 88 (manuscript received 16 Jun 87) pp 799-807*

[Article by A. R. Smirnov and V. A. Moskalenko, Low Temperatures Physical Technical Institute, Ukrainian Academy of Sciences]

[Abstract] There is little information in the literature on the influence of deformation rate on substructure, particularly in the range of moderate speeds. Information obtained by structural methods can explain the peculiarities of the mechanical properties of materials at various deformation rates and as the rates change. This article presents such a study, performed on technically pure type VT1-00 titanium foil 0.1 mm thick. Specimens were cut in the direction of rolling, annealed for 1 hour at 780°C in a vacuum, yielding an average grain size of about 50 µm. They were then tensile tested at room

temperature at  $2 \cdot 10^{-5}$ - $2 \cdot 10^{-2}$  s<sup>-1</sup>. Electron-microscope images were produced and statistically processed, determining that as deformation rate decreases, the probability of the formation of rotational substructures increases and that of formation of translational substructures decreases. Thus, the question of the influence of the deformation rate on the level of deformation stresses must be answered considering the variation of the probability of the formation of rotational and translational substructures with speed. Furthermore, the kinetics of the development of the parameters characterizing these substructures must be considered. References 16: 10 Russian, 6 Western (3 in Russian translation).

UDC 669.24'295:669.788:620.18

### Influence of Hydrogen on Nature and Sequence of Thermoelastic Martensite Transformations in Alloys Based on Titanium Nickelide

18420062a Moscow METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 10, Oct 88 pp 6-10

[Article by S. B. Maslenkov, N. B. Budigina, M. Kh. Shorshorov, and Yu. M. Flomenblit]

[Abstract] An x-ray structural analysis was made to ascertain the nature and sequence of martensite transformations during the heating of hydrogenated alloys. The temperatures of the phase transformations were determined by the differential thermal analysis method. Hydrogenation of the investigated alloys was by the electrochemical method in a 4 percent sulfuric acid solution. In hydrogenated alloys based on titanium nickelide the martensite induced by hydrogen experiences a reverse martensite transformation at considerably higher temperatures than in the absence of hydrogen. The existence of a "hydrogen" martensite was observed in alloys with 3 percent Fe in which a martensite phase is formed only after cooling to the temperature of liquid nitrogen. With the heating of hydrogenated alloys there is a change in the ordinary sequence of martensite transformations, attributable to the different influence of hydrogen on the thermal stability of the R-phase and "hydrogen" martensite. References 7: all Russian.

UDC 539.431:669.295

### Fatigue Strength of Titanium Alloy VT23 in Tests With High Loading Frequency

18420062f METALLOVEDENIYE I  
TERMICHESKAYA OBRABOTKA METALLOV in  
Russian No 10, Oct 88 pp 46-48

[Article by L. Ye. Matokhnyuk, A. V. Voynalovich, A. A. Khlyapov, S. G. Bulgakova, and V. P. Artyushina]

[Abstract] The influence of strengthening heat treatment on the fatigue strength of the high-strength titanium alloy VT23 was investigated. A rod with a diameter of 110 mm, a plate with a thickness of 100 mm and a

hot-rolled tube (diameter 160 mm and wall thickness 22 mm) were investigated. The semifinished products were subjected to annealing at 800°C for 1 hour with air cooling and also strengthening heat treatment (annealing with subsequent aging at 500°C for 10 hours). It was found that strengthening with aging promotes a considerable increase in the fatigue strength of the alloy. For example, for smooth specimens from plate the fatigue limit with a loading frequency of 10 kHz is increased by approximately 60 N/mm<sup>2</sup> and for tube specimens by 40 N/mm<sup>2</sup>. Under all conditions of the tests conducted the fatigue limit for specimens cut from tube is greater than for the specimens fabricated from plate. The loading frequency exerts an influence on fatigue strength. With a change in loading frequency from 0.46 to 10 kHz the fatigue limit of smooth specimens of plate in the annealed state increases by 75 N/mm<sup>2</sup>. A similar result was obtained for tubes and semifinished products in a hardened state. The fatigue limit of this alloy therefore increases monotonically with an increase in loading frequency from 0.46 to 10 kHz. An equation is derived which makes it possible to determine the fatigue limit for an alloy at a lower frequency from the results of high-frequency tests. References 7: all Russian.

UDC 541.16

### Electron Structure of Hydrogen-Containing Carbide, Nitride, and Oxide Compounds of Titanium and Vanadium

18420082a Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 24 No 10, Oct 88 (manuscript received 29 Oct 86) pp 1654-1660

[Article by A. L. Ivanovsky, V. A. Gubanov, and A. V. Bekshayev, Chemistry Institute, Ural Department, USSR Academy of Sciences]

[Abstract] Many physicochemical and electron characteristics of the compounds and solid solutions forming in M-C-N-O systems have been adequately studied, but information on the influence of hydrogen, which is frequently present in these phases, on the properties of solid solutions is limited and little has been published on the electron structure and chemical bonding of these hydrogen-containing multicomponent compounds. A quantum chemical study was therefore made of electron distributions and chemical bonding for two- and three-component cubic compounds of variable composition arising in such systems and containing a hydrogen admixture as a function of the composition of the metallic and metalloid sublattices, the presence of metalloid defects and possible types of nonequivalent positions (interstitial and substitution) occupied by admixture atoms in the matrix volume. Nineteen-atom fragments of the composition MX<sub>6</sub>M<sub>12</sub> (M-Ti, V; X-C, N, O) were used as a model for describing the phases investigated (NaCl type structure). Ninety-four clusters were computed using the semiempirical MWH method. On the basis of the computations of clusters simulating binary and ternary complete and imperfect compounds

containing H atoms in different highly symmetric interstitial and substitution positions important information was obtained on the mechanisms of the formation of hydrogen-containing compounds as a function of the degree of completeness and the composition of the initial phase sublattices. References 8: 6 Russian, 2 Western (in Russian translation).

UDC 669.018.15:621.762

### Structural Features of Titanium Carbide Powders

18420082b Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA NEORGANICHESKIYE MATERIALY in Russian Vol 24 No 10, Oct 88 (manuscript received 16 May 83) pp 1726-1730

[Article by A. M. Bogomolov, G. T. Dzodziyev, Yu. A. Pak, A. A. Kalkov, V. F. Rezvykh, A. P. Shuvayev, and L. K. Karimova, All-Union Scientific-Research and Design Institute for Refractory Metals and Hard Alloys]

[Abstract] The physicomechanical properties of many newly developed materials are determined by the structure and properties of the titanium carbide used in their fabrication, depending on its composition and methods of production. An x-ray structural analysis was made to determine the elementary cell parameter, substructure elements, concentrations of simple packing defects ( $\alpha$ ), rms static and dynamic displacements and Debye temperature in titanium carbides obtained by the carbothermal and plasmochemical methods and the method of self-propagating high-temperature synthesis (SPHTS). A study was also made of the thermal stability of carbothermal and SPHTS carbides and the oxygen concentration in the powders was determined. A table gives a comparison of the structural parameters of specimens of titanium carbide obtained by the three methods. For example, a distinctive feature of SPHTS powders is high rms static displacements. In order of increase of rms static displacements the powders can be arranged in the following series: carbothermal-plasmochemical-SPHTS. The concentrations of packing defects in plasmochemical and SPHTS powders differ little from one another; their values are lower than in carbothermal powders. In general, the  $\alpha$  value for carbides obtained by different methods are close to those obtained for pure copper and silver and in the double metallic alloy Cu + 20 percent Zn. With respect to Debye temperature, the carbothermal and SPHTS powders are virtually the same and the dynamic displacements for carbothermal and SPHTS powders differ little from one another. References 20: 18 Russian, 2 Western (in Russian translation).

UDC 669.285.621.791.052

### Phase Composition of Welded Joints of Heat-Resistant BT-9 Titanium Alloy

18420094b Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 5, Sep-Oct 88 (manuscript received 16 Jun 87) pp 95-98

[Article by F. I. Azamatova, N. N. Ganzhula, B. A. Zaderiy, Ya. B. Nudelman, V. S. Tatarchuk, and T. V. Shevchuk, Kiev]

[Abstract] The influence of electron-beam welding and subsequent heat treatment on changes in the structure

and properties of welded joints of BT-9 titanium alloy was studied. Plates of the alloy, preliminarily annealed in a vacuum furnace at 900°C for 1 hour, were welded by electron-beam welding under various conditions. The joints were then mechanically tested and examined under an optical microscope. The structural state was studied by x-ray diffraction methods in monochromatic cobalt radiation. Electron-beam welding generated a heterogeneous structure, from the coarse crystalline structure of the molten seam metal and recrystallized heat-affected zone to the structure of the base metal. The heat-affected zone had a 0.2-0.3 mm wide area with an elevated content of impurity hydrogen and oxygen which etched more easily. The mechanical properties were found to be independent of welding conditions, with hardness increasing and impact toughness decreasing from the seam metal to the base metal. It is concluded that rapid cooling from the fusion temperature forms a martensitic  $\alpha'$  phase which increases the hardness and decreases the ductility of the seam zone. Titanium and zirconium silicides were found in the heat-affected zone. The presence of the silicide decreases impact toughness, increases hardness and increases the content of hydrogen and etchability in corrosive media. The use of subsequent heat treatment can dissolve the silicides and improve the properties of the metal. References 7: 5 Russian, 2 Western.

UDC 620.187:666.762.11

### Structure Formation Mechanism and Defect Content of $\text{Al}_2\text{O}_3$ -TiC Ceramics

18420095a Kiev SVERKHTVERDYYE MATERIALY in Russian No 5, Sep-Oct 88 (manuscript received 6 Jul 87) pp 17-22

[Article by A. N. Pilyanovich, V. A. Melnikova, and A. I. Kulik, Institute of Materials Science Problems, Ukrainian Academy of Sciences, Kiev]

[Abstract] A study is made of the interphase interaction among initial charge components in an  $\text{Al}_2\text{O}_3$ -TiC ceramic, the compacting mechanism during sintering, the type of fracture, structural defects and hardening effects occurring at the substructural level. Electron microscope and x-ray studies were performed on materials made by hot pressing and containing 20, 40 and 60 percent TiC by mass. Increasing TiC content over 20 percent is found to cause a change in dispersion, disruption of the isolation of carbide grains from each other and the appearance of a stress relaxation mechanism resulting not from microplasticity, but rather from the formation of microscopic cracks, twins and packing defects, all causing a decrease in the strength of the material. References 8: all Russian.

UDC 621.762

### Mechanical Properties and Wear Resistance of Polycrystalline Superhard Material With Titanium Nitride-Based Binder

18420095b Kiev SVERKHTVERDYYE MATERIALY in Russian No 5, Sep-Oct 88 (manuscript received 24 Sep 87) pp 22-24

[Article by I. M. Androsov, V. T. Vesna, and V. P. Maslov, Superhard Materials Institute, Ukrainian Academy of Sciences, Kiev]

[Abstract] A study is made of the mechanical properties and wear resistance of a polycrystalline superhard material containing 5-40 percent binder by mass manufactured by hot pressing of microscopic KM 10/7 cubonite powder at 5 GPa under conditions of the thermodynamic stability of the cubic boron nitride. The binder was a hypoeutectic TiN-TiB<sub>2</sub> alloy produced by gas-phase precipitation. Mechanical properties were studied on disk specimens by determining tensile strength under diametric compression of a disk specimen. Disk specimens with a central notch were used to determine crack resistance. It was found that tensile strength increased monotonically with increasing binder content, indicating the primarily intercrystalline nature of fracture. Wear resistance was at its maximum with 20-35 percent binder by mass. The new materials were found to have at least double the wear resistance of 05IT elements. References 7: all Russian.

UDC 629.735.33.015.4:620.18

**Crack Development Resistance of Large Pressed and Rolled Intermediate Products of New Aluminum Alloys**

*18420055c Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 9, Sep 88 pp 8-11*

[Article by A. G. Vovnyanko, L. A. Bukreyeva, and Ye. A. Zakharenko]

[Abstract] A study was made of the crack growth rate  $v = dl/dN$  during cyclical testing in the range of  $K_{max}$  most interesting to designers with the stress intensity factors typical for large panels used as airplane wing load-bearing structures. Tests were performed on the new aluminum alloys 1161, 1163 and 1973, which have improved properties. The crack growth rate in 1163 alloy was 1.2 to 2 times slower than in the older D16ch alloy. Crack growth rate in pressed panels was 1.5 times lower than in rolled panels of both alloys. Still lower growth rates were observed in pressed panels of 1161 alloy. In 1973 alloy, no difference between rolled and pressed panels was observed. References 5: all Russian.

UDC 669.33-492.2

**Structure and Properties of Electrical-Engineering Materials Made From Copper Powders**

*18420031a Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 20-23*

[Article by Ya. A. Gluskin, Yu. A. Shesterin, R. G. Pryadkina, G. A. Potasheva, and T. Yu. Smirnova]

[Abstract] A comprehensive study of three Cu powders (PMR-1 atomized powder from the Alaverdi Mining and Metallurgical Combine, PMR-1(0) annealed atomized powder, and PMS-1 electrolytic powder as well as 1:1 mixtures of PMR-1 and PMS-1 powders) was made, its purpose being an evaluation of their physical properties

(bulk density, specific surface area, fluidity, microhardness) and technological characteristics determining their sinterability and the usefulness of compacts as electrical-engineering materials. The study included chemical analysis and morphological analysis of powder specimens as well as mechanical testing of compact specimens for Brinell hardness, tensile strength, flexural strength, and percentage elongation and fractography under an ISM-35SCF scanning electron microscope. The results indicate that atomized Cu powder needs to be annealed for improvement of its otherwise inadequate sinterability and that an admixture of electrolytic Cu powder will improve the mechanical characteristics of compacts. References 6: all Russian.

UDC 621.762.2

**Production of Tin Powder With Low Oxygen Content**

*18420031b Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 26-28*

[Article by Sh. M. Sheykhaliyev]

[Abstract] Seven methods of producing tin powder from a melt so as to ensure a low oxygen content are comparatively evaluated with respect to technical indicators (size fractions of powder grains, bulk density of powder, fluidity, mass concentration of O<sub>2</sub>) as well as economic indicators (energy consumption and energy cost per kg of powder). These methods are: 1) atomization by Ar jet under 0.2 MPa pressure, 2) atomization by N<sub>2</sub> jet under 0.2 MPa or 1.0 MPa pressure, 3) atomization under vacuum by electric current pulses with 100 J energy each (voltage up to 275 V) at a repetition rate of 50-60 Hz, 4) acoustic atomization by gas stream pulsating at ultrasonic frequency, 5) ultrasonic atomization by capillary waves generated by magnetostrictive transducer, 6) atomization by hydrodynamic forces in centrifuge under 0.8-1.2 MPa pressure head, 7) atomization by combined eddying action of centrifugal forces and gas (Ar) jet. The data indicate electric-pulse method yields coarse-grain tin powder at a low cost, both ultrasonic and centrifugal methods yield medium-grain tin powder at a low cost, and the eddy method yields fine-grain tin powder at a lower cost than does the acoustic method or a gas jet alone. References 10: all Russian.

UDC 669.243

**Dependence of Crushability of Cu-Ni Matte on Its Composition**

*18420031c Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 37-39*

[Article by M. Ye. Bykov, V. A. Tsukerman, and V. V. Goncharov]

[Abstract] Wet crushing of Cu-Ni matte is considered, this material being treated as a mixture of three phases: (CuS, NiS, Ni). The dependence of the process kinetics

on the matte composition is evaluated on the basis of an open-cycle laboratory experiment. A crusher was loaded to 12 pct of its  $3.23 \text{ dm}^3$  capacity with lump specimens of the 25 mm size fraction and the barrel rotated at a speed of 94 rpm. The balls, 4.25 mm and 15 mm in diameter, weighed 6.8 kg and occupied 45 pct of the barrel volume. The duration of a crushing cycle was varied from 10 min to 210 min. The results of screen and phase analyses reveal an exponentially decreasing comminution rate, with NiS crushing faster than CuS so that initially the Ni content decreases and the Cu content increases in the larger fractions and with metallic Ni crushing slower than CuS. References 6: all Russian.

UDC 669.045.5

#### **Conversion of Nickel Matte by Oxygen-Depleted Blast**

*18420031d Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 39-41*

[Article by A. A. Galnbek, N. M. Barsukov, M. R. Rusakov, O. Yu. Alekseyeva, A. A. Pashkovskiy, and A. F. Pronin]

[Abstract] Conversion of Ni matte by the blast process in the plants of the Yuzhurnalnikel Combine is analyzed for the effectiveness of oxygen depletion in the blast, a low oxygen content in the air stream being readily attainable by dilution with an inert gas and by insertion of tubular shields into the tuyeres. An analysis of the heat balance and of the metal extraction kinetics confirms that oxygen depletion will not only lengthen the life of converter lining but also boost extraction of nonferrous metals (Ni, Co) in the plants of the Yuzhurnalnikel Combine. References 3: all Russian.

UDC 628.543:661.25

#### **Precipitation of Arsenic From $\text{H}_2\text{SO}_4$ Solutions With Aid of Sulfide Reagents**

*18420031e Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 46-49*

[Article by O. G. Perederiy, A. Ye. Sokolov, N. Ya. Lyubman, and V. Ye. Ziberov]

[Abstract] Extraction of arsenic from its compounds in rinse solutions containing  $\text{H}_2\text{SO}_4$  by precipitation of its sulfide with the aid of another sulfide is analyzed quantitatively on the basis of thermodynamic equilibria in the  $\text{NaHS}-\text{HAsO}_2-\text{H}_3\text{AsO}_3-\text{H}_2\text{SO}_4-\text{H}_2\text{O}$  system. The equilibrium constant is calculated for 16 possible reactions in this system, its logarithm being proportional to the change of Gibbs energy. Seven of these reactions yield  $\text{As}_2\text{S}_3$  and three reactions yield  $\text{H}_2\text{S}$ , the latter ones determining the oxidation-reduction potential at the end of the process. That potential and the As concentration, both depending on the dose of sulfide sulfur and its rate of consumption, determine the technological conditions for As extraction at a constant rate, which decreases with rising temperature.

Such a technology of As removal from rinse solutions has been developed and has been introduced at the plants of the Alaverdi Mining and Metallurgical Combine in 1987. It will be adopted by the Balkhash Mining and Metallurgical Combine in 1988. References 8: 6 Russian, 2 Western (both in Russian translation).

UDC 669.292.3:669.782:66.013

#### **Extraction of Rare and Heavy Nonferrous Metals From Solutions**

*18420031f Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 67-70*

[Article by A. M. Kasimov and Yu. P. Velichko]

[Abstract] Extraction of pentavalent vanadium in its compounds or commercial  $\text{V}_2\text{O}_5$  from industrial waste water containing up to  $25 \text{ g/dm}^3$   $\text{V}_2\text{O}_5$  has been improved by a new technology which ensures adequate heat and mass transfer from the steam to the treated solution and to the precipitating solid phase. The high-temperature hydrolysis takes place in special jet reactors acting simultaneously as conveyors and heat pumps. Fast and thorough final extraction from already depleted solution without irreversible loss of vanadium and without pollution of the air is facilitated by addition of cationic surfactants forming insoluble vanadium compounds. Another metal extractable by this appropriately modified technology is niobium when up to  $0.002 \text{ mg/dm}^3$  of it in the form of  $\text{K}_2\text{NbF}_7$  and  $\text{K}_2\text{NbOF}_5$  salts can be found. Lixiviation of W-Mo concentrate with sodium in an autoclave is facilitated by addition of anionic sorbents such as organic oils (oleic acid, sodium oleate) and foaming inhibitors such as organosilicon compounds (polymethyl siloxane),  $\text{SiO}_2$  being then removed by hydrolysis and neutralization of the solution with a mineral acid to pH 9-8.2 at 95-100 deg C in bubbling live steam. References 1: Russian.

UDC 621.771.016.3.01-616:669.71

#### **Appropriate Range of Unit Tension for Rolling Aluminum Foil**

*18420031g Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 82-83*

[Article by L. B. Zlotin and M. A. Tikhachev]

[Abstract] The appropriate range of unit tension for cold rolling of aluminum foil is established theoretically considering that the rolling process becomes unstable with the edges wrinkling under insufficient tension and that necking with eventual rupture occurs under excessive tension. The critical compressive stress for loss of planarity is calculated according to the theory of elasticity for thin plates. Numerical calculations have been made for rolling a 1530 mm wide sheet of A5 aluminum from 0.200 mm to 0.014 mm thick, assuming a stress concentration factor of 1.7 and a square-law variation of unit tension over the width. These calculations, supported by experimental data, indicate that the unit tension should be within 25-35

pct of the tensile strength with plus or minus 15 pct regulation. References 4: all Russian.

UDC 621.928.8:662.49

**Extraction of Nonferrous Metals From Secondary Sources by Electrodynamic Separation**  
*18420031h Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 83-85*

[Article by L. A. Barskiy and I. M. Bondar]

[Abstract] Use of electrodynamic separators for extraction of nonferrous metals from secondary sources by the dressing process is considered the most effective being separators with rotating permanent magnets. Design and performance analysis of such permanent magnets is outlined, six materials ( $\text{SmCo}_5$ , Pt-Co, Ti-Co-Ni, Al-Ni-Co, Ba ferrite, cobalt steel) with an energy product  $(\text{BH})_{\max}$  of 200.0, 93.6, 88.0, 68.8, 28.0, 5.2 respectively being considered for this application. References 5: all Russian.

UDC 681.938:65.011.56.001.12

**Computer-Aided Design of Production Machining Technology for Parts Made of Aluminum Alloys**  
*18420031i Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 101-103*

[Article by B. A. Prudkovskiy, A. A. Igumenov, and Ye. M. Makarov]

[Abstract] Following a review of software generally needed for computer-aided design, a special software is described which has been developed for design of a technology involving use of machine tools with numerical program control for producing parts made of aluminum alloys. This software includes application programs and standard subroutines also stored in a "technological file," the hardware including magnetic storage devices. With this computer-aided design facility it becomes possible to both expedite production orders and improve the product quality. References 6: all Russian.

UDC 681.621.774.04-52

**Use of Multicriterial Optimization Procedures in Computer-Aided Design of Processes and Equipment**  
*18420031j Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 104-106*

[Article by P. V. Sevastyanov]

[Abstract] Multicriterial optimization procedures based on the theory of indistinct sets have been applied to computer-aided design of processes and equipment in

the nonferrous metals industry so that qualitative relations between criteria and constraints can be adequately described disregarding any subjective preference. Criteria and constraints are formulated in the form of preference functions in a technological language. The program packet consists of three functional parts: 1) regression analysis of data for simplification of mathematical models; 2) calculation of absolute ranks; 3) extremum search by the method of successive quadratic approximation. Regression analysis is performed on the basis of a reliable mathematical model, if available, or on the basis of accumulated empirical data. The program for rolling aluminum alloys in the model 2800 continuous-duty five-stand mill designed at the Mogilev Department of the Physical Technical Institute of the Belorussian Academy of Sciences contains altogether 23 criteria and constraints, 29 input and output variables, and 7 equations. The execution of the design algorithms is outlined on a simple example of water-cooled rollers acting also as crystallizers, the object being to optimize the roller dimensions and the coolant flow rate as well as the casting rate. References 7: 5 Russian, 2 Western (1 in Russian translation).

UDC 65.011.56.001.12

**Development of Computer-Aided Design at State Scientific Research and Design Institute of the Rare Metals Industry (Giredmet)**  
*18420031k Moscow TSVETNYYE METALLY in Russian No 8, Aug 88 pp 106-108*

[Article by V. N. Lippikh, Yu. Ya. Olskiy, and Yu. M. Rybkin]

[Abstract] Since a special department for automation of research and engineering was formed at the State Scientific Research and Design Institute of Rare Metals Industry in 1982, a multitude of programs applicable to this industry has been developed for computer-aided design on a YeS-1060 computer, an SM-1420 mini-computer, or on a LABTAM personal computer. At the same time, many programs developed at institutes of the USSR State Committee for Construction Affairs and others have been directly utilized or adapted for solving general engineering problems in this particular industry. The feasibility of updating both hardware and software of this industry's computer-aided design system for compatibility with modern database management is now being studied by a task force forming the nucleus of a future service organization.

UDC 669.15-194.56:621.785.375:539.217.001

**Development of Helium Porosity During Annealing of Austenitic Stainless Steel**  
18420099a Sverdlovsk FIZIKA METALLOVI METALLOVEDENIYE in Russian Vol 66 No 4, Oct 88 (manuscript received 17 Mar 87) pp 722-726

[Article by V. F. Chkuaseli]

[Abstract] A theoretical study is presented of the development of gas porosity during annealing of helium-saturated stainless steel to determine the basic pore growth mechanisms. The experimental data are described by a theoretical model in which the evolution of pore distribution by dimensions resulting from collision and merging of randomly wandering pores is considered in a defect-free portion of a grain, on dislocations and at grain boundaries, starting from a solid solution of gas atoms. Pores are considered spherical and in equilibrium. The basic pore growth mechanism is merging as they move by volumetric diffusion. At 1023 K, the predominant pore growth mechanism is absorption of vacancies by pores during which equilibrium is not preserved. As equilibrium gas porosity is formed, which requires about 10 hours or more, merging of pores by surface diffusion begins to predominate. Bimodal pore size distribution under heavy load is not explained by the theory. References 13: 1 Russian, 12 Western.

UDC 669.14.018.8

**Influence of Structural Heterogeneity on Corrosion Resistance of 02Kh8N22S6 Steel**

18420049h Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 24 No 4, Jul-Aug 88 (manuscript received 12 May 87) pp 118-120

[Article by V. N. Lipodayev, K. A. Yushchenko, L. D. Tikhonovskaya, and V. Yu. Skulskiy, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences, Kiev]

[Abstract] In order to establish the conditions for the formation of a structure with strictly directed excess phase segregations in high-silicon steel, several types of heat treatment were performed. Metallographic studies of the heat-treated and corrosion-tested specimens revealed that heat treatment significantly influences the formation of structural type and the nature of corrosion damage. Thus, treatment at 780 and 830°C causes segregation of excess phases along grain boundaries and facilitates intercrystalline corrosion. However at these same temperatures there is some oriented segregation of dispersed phases, particularly at 830°C. Orientated segregations reach their maximum at 900°C in relatively large austenite grains. Subsequent tempering at 700°C leaves the nature of excess phase segregation virtually unchanged. Treatment at 1250°C results in the formation of extended silicide-phase segregations and smaller, compact segregations. Alloying with niobium does not influence the oriented segregation of excess phases at about 900°C. References 3: all Russian.

UDC 621.793:621.373.826

**Influence of Laser Treatment on Structure of a Spray-Coated Layer**

18420090a Moscow *IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA* in Russian No 11, Nov 88  
(manuscript received 11 Apr 88) pp 84-86

[Article by V. L. Pilyushenko, V. A. Belevitin, Yu. V. Zelenskiy, I. Yu. Machikina, and A. N. Smirnov, Donetsk Polytechnical Institute]

[Abstract] Parts of ShKh15 steel, with VK20 WC-Co hard-alloy coatings applied by plasma spraying, were studied. Laser treatment of the plasma coating 250-300  $\mu\text{m}$  thick was performed, melting the coating completely with continuous laser power of 20 kW/cm<sup>2</sup>, part speed of 3.0 mm/s and 10-20 percent defocusing. The plasma-sprayed coatings had many pores located in groups and chains. Defects covered 9-17 percent of the sprayed coating area. Laser treatment significantly improved the condition of the plasma-sprayed layer, causing pores to combine, become spherical and rise to the surface. Defects occupied 1.5-4 percent of the surface area and small cavities 5-20  $\mu\text{m}$  in diameter were evenly distributed through the coating. Various types of defects in the transition zone were virtually completely eliminated by laser treatment.

UDC 621.78.013.001.57

**Permissible Intensity of Low-Temperature, High-Speed Jet Heating of Metal**

18420090b Moscow *IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA* in Russian No 11, Nov 88  
(manuscript received 9 Dec 87) pp 128-131

[Article by P. G. Krasnokutskiy, V. A. Krivandin, Ye. N. Trikashnaya, and A. V. Shpernyy, Zaporozhye Machine-Building Institute]

[Abstract] Algorithms for the solution and results of the computation of the permissible intensity of low-temperature heating of cylindrical blanks following cutting on a press are presented. The problem of determining the permissible intensity of low-temperature heating, or permissible heat-flux density at the surface, is one of selecting the total heat transfer coefficient as a function of time which provides the minimum heating time, while meeting necessary limitations as to permissible tensile stresses, surface temperature and temperature uniformity. It is found that the thickness and thermophysical

and mechanical properties of the specimen have the greatest influence on permissible maximum heating intensity. References 3: all Russian.

UDC 669.187.56:621.9.015.62-412.001.5

**Surface Quality Classification of Cast Electric-Slag Tool Blanks**

18420100a Kiev *PROBLEMY SPETSIALNOY ELEKTROMETALLURGII* in Russian No 4, Oct-Dec 88 (manuscript received 25 Sep 87) pp 22-27

[Article by V. B. Linetskiy, G. A. Boyko, B. I. Medovar, and A. G. Miroshnichenko, Scientific-Production Association of the Scientific Research Institute of Steel Castings (NIISL), Odessa; Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences, Kiev]

[Abstract] The purpose of this work was to refine the existing classification of electric slag casting surface defects and develop a scale of electric slag casting surface roughness by analysis of statistical data on the quality of casting surfaces, refining the existing classification of surface defects as applicable to tool blanks, constructing a scale of surface defects, analyzing the causes of their formation and developing recommendations for their elimination, and by ranking the scale of defects and developing a scale for casting surface roughness. The studies showed a number of previously unclassified electric slag casting surface defects such as dendritic structures. The result of the study was a new "scale of electric slag casting surface roughness," permitting the technological parameters of a process to be monitored, the microstructure of castings to be predicted and, thus, the technological route to be followed in the manufacture of tools to be determined. References 5: all Russian.

UDC 620.18:621.785:621.3.038.8

**Structure and Properties of Eutectic Alloys in Laser Fusion Zone**

18420062c Moscow *METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV* in Russian No 10, Oct 88 pp 30-34

[Article by A. B. Lysenko, N. N. Kozina, and L. I. Mirkin, Dneprodzerzhinsk Industrial Institute; Mechanics Institute, Moscow State University]

[Abstract] A study was made of the phase composition, microstructure and microhardness of alloys of the eutectic type based on iron, rare earth elements (Ce, Pz) and alloys of the Ni-P system in the fusion zone caused by irradiation by a pulsed laser. Metallographic and x-ray structural analyses of the specimens treated were made. It was found that with irradiation by solid-state lasers with a pulse duration of approximately  $10^{-7}\text{s}$  local sectors of the fused zone of several tested alloys exhibit noncrystalline hardening. Amorphous sectors of the surface layer of alloys are characterized by the absence of

etchability, high microhardness and increased brittleness of the alloys. With a decrease in light flux power density the tendency towards cracking in the fusion zone decreases. Laser irradiation of chemically active rare-earth metal alloys is accompanied by oxidation of the fused zone surface. The formation of an oxide film and the relatively low thermal conductivity of the eutectic matrix worsen heat removal conditions and do not make it possible to obtain metastable structural states in the treated layer. References 6: 4 Russian, 2 Western.

UDC 621.79

### Possibility of Using Irradiation by High-Energy Electrons for Alloying Materials

18420077c *IZVESTIYA AKADEMII NAUK SSSR: SERIYA METALLY* in Russian No 5, Sep-Oct 88  
(manuscript received 20 Apr 87) pp 128-133

[Article by R. A. Vladimirs'kiy, V. B. Livshits, V. A. Payuk, S. V. Plotnikov, and V. A. Kuzminykh, Moscow]

[Abstract] Irradiation of metals and semiconductors by a beam of fast electrons with an energy greater than 2.5 MeV enables researchers to transform the physicomechanical properties of surface layers by alloying them with different elements or by redistributing the admixtures of the alloy elements at a considerable depth. Mass transfer differs in its intensity in heterogeneous and homogeneous systems. In heterogeneous systems it has a complex character which is dependent on the electron energy, current density in the beam, specimen temperature and the combination and relative positioning of the elements. The study of this phenomenon under a variety of conditions included: distribution of Cr and Fe before and after irradiation of 40Kh steel with a layer of 20  $\mu\text{m}$  of chromium carbides by 4.0-MeV electrons; steel specimen after irradiation by 6-MeV electrons; distribution of Cr, Fe and Ni in 40Kh steel with 7- $\mu\text{m}$  Ni layer after irradiation by 10-MeV electrons; distribution of absorbed dose in a Ni specimen; distribution of concentration of element in a specimen. It is shown that such irradiation results in the formation of a considerable

temperature gradient in the sample near the surface and a nonequilibrium concentration of defects. In addition to an increase in the effective diffusion coefficient a nonuniform distribution of temperature and defects results in the appearance of uncompensated flows of atoms, resulting in the redistribution of the elements. As a result there is drift of one of the elements through the layer of a second element. The gradient of temperature and defects, the medium temperature and the ratio of the migration activation energies of the atoms of the elements are decisive factors in the anomalous mass transfer resulting from irradiation. References 9: 4 Russian, 5 Western (1 in Russian translation).

### Hardening of Metal Ceramic Hard Alloys Based on Tungsten and Titanium Carbides by Laser Radiation

18420101a *Kishinev ELEKTRONNAYA OBRABOTKA MATERIALOV* in Russian No 5, Sep-Oct 88  
(manuscript received 20 Oct 86) pp 14-17

[Article by V. N. Filimonenko and A. I. Zhuravlev, Novosibirsk]

[Abstract] The structural and phase changes occurring upon laser hardening of VK2-VK30 were studied using pulses of a neodymium laser with pulse length varying from  $10^{-7}$  to  $2 \cdot 10^{-3}$  s and power density varying from  $10^5$  to  $2 \cdot 10^8 \text{ W/cm}^2$ , with initial temperatures of 20-900°C. X-ray structural studies showed that the phase composition changes only in the melted layer of the surface. This melted layer also experiences changes in micro- and macrostructure. Beneath the melted zone is a transition zone in which the shape of the WC grains changes and the thickness of the cementing binder layers increases. Rapid heating and cooling results in the appearance of significant residual macro-stresses, which influence the strength and usage characteristics of the alloys. The amount of increase in service life depends greatly on the temperature of annealing performed after radiation treatment. Radiation treatment increases the probability that a tool will fail due to flaking or fracture of the cutting edge rather than wear. References 4: all Russian.

UDC 629.113.002.72:621.757:621.791

**Welding and Assembly**

*18420007a Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 5, May 88 pp 31-33*

[Unsigned article: "Welding and Assembly." Passages in boldface as published]

**[Text] Welding has been firmly introduced into motor-vehicle manufacturing for a long time because it, and particularly its automated methods, makes it possible to make do with a small number of workers, increases the reliability of joints and the rigidity of vehicle bodies and cabs, and saves metal, metalware, energy, and money.**

**The measures aimed at the acceleration of scientific and technical progress in our industry provide for continued development and improvement of the technology and equipment for all methods of welding.**

For example, the inventory of friction-welding machines will at least double during the 12th Five-Year Plan. The use of methods such as laser welding and plasma-arc welding will continue to increase. There will be considerably more welding robots, particularly in the production of car bodies, where, having become part of a flexible production system, they make it possible to weld several body types on the same line and to quickly master the production of new automobile models.

**Automation and introduction of modern technologies and equipment apply not only to welding but also to assembly operations. This is one of the main thrusts in the development of industrial technology, because assembly in automobile manufacture represents a large share of the total expenditure of labor and time.**

**The most interesting examples of welding and assembly equipment shown at the USSR VDNKh [Exhibition of Achievements of the National Economy (Moscow)] are discussed below.**

The AvtoVAZ Production association has developed and produced robots equipped for welding. They are used at welding stations for BAZ-1111 and VAZ-2108 passenger-car bodies. A welding station consists of an industrial robot (model PR 161/60 or 601/60) equipped for welding and a platform for mounting the robot and supporting and clamping the article being welded.

A programmable finish-welding-station robot is turned on when a car body or a front end, which has been prewelded at strategic points, is placed on the platform and clamped. The PR 161/60 robot welds 50 points (30 on the body and 20 on the front end), and the PR 601/60 robot welds 52 points.

**Technical Data of Robot Models PR 161/60 and PR 601/60**

	PR 161/60	PR 601/60
Degrees of freedom (axes)	6.0	6.0
Load capacity, kg	60.0	60.0
Precision of positioning, mm	+ or - 0.5	+ or - 1.2
Working space volume, m <sup>3</sup>	14.5-28.5	37.0
Maximum power used at PV 70%, kVA	13.0	25.0
Noise level outside working zone, dB	less than 75.0	less than 85.0
Weight without equipment, kg	1,700.0	2,000.0

Friction-welding machine model PST-60 is used to weld blanks made from like and unlike materials. It consists of a frame housing, a movable spindle assembly unit with its rotary drive, hydraulic cylinders for fast and working-speed feed of the crosshead, and universal clamping devices for clamping of rotating and stationary cylindrical blanks. At customers' request, it can be equipped with special clamping devices and devices for external and internal deburring and for feeding and removal of blanks.

The control system of the machine is equipped with a special modular hydraulic station and a Tesla NS-915 programmable controller. It provides for automation of the welding process and control of the limit values of the parameters, self-diagnosis, and quick resetting when the welding parameters or the dimensions of the blanks being welded are changed.

Compared to similar domestic and foreign machines, it offers a higher efficiency of the hydraulic drive and of the spindle drive (15-20 percent higher), a high precision of the welds, a higher operational versatility, and improved properties related to human engineering, industrial hygiene, and ecology.

**Technical Data of Model PST-60 Machine**

Axial compression force, kN	600
Productivity, welds/h	60
Rotary-drive power, kW	75
Total operating power, kW	95
Spindle speed, rpm	1,000
Overall dimensions, mm:	
semiautomatic machine	4,400 X 1,400 X 1,900
control cabinet	1,100 X 6,500 X 2,100
hydraulic station	1,400 X 1,150 X 1,300
Total weight, kg	10,500

The total economic effect of introducing one machine is 50,000 rubles.

The machine was developed by the NIITavtoprom [Scientific-Research Technological Institute for the Automobile Industry] Scientific-Production Association and built by the Chelyabinsk Tractor-Trailer Machine-Building Plant.

The automatic machine model 5083 is used to assemble the internal-combustion-engine tensioning pulleys with two ballbearings, a retaining ring, and a shaft.

The following equipment is mounted on the automatic-machine support: a vertically closed step-wise conveyer with attachments, pneumatic presses for assembling of parts, three rotary tables for the retaining rings, a vibrating bin and a model MP-9S robot for feeding and installation of the shafts, and a bearing-lubrication station.

The assembly is carried out at six working positions. At the first position the pulley is placed in an attachment on the conveyer. The bearings are pressed in at the second and third positions, the required quantity of VNII NO-207 grease being added together with the bearing at the third position. The retaining ring is installed in the pulley at the fourth position, and the pulley shaft is pressed in at the fifth position. The properly aligned shafts go from the vibrating bin to the gripping device of the robot, which carries them to the assembly point. At the sixth position, the assemblies are removed from the conveyer attachment and placed in a collector.

All positions are equipped with devices that monitor the presence of the parts and the correctness of their installation. The control system of the automated machine is based on the programmable controller.

#### Technical Data of Model 5083 Automated Machine

Productivity at 75% utilization, units/h	180
Cycle time, s	15
Maximum press force, N:	
for bearings	4,000
for shafts	3,000
Cassette capacity, each	
for pulleys	60
for bearings	160
for retaining rings	360
Compressed-air consumption, nm <sup>3</sup> /h	71
Overall dimensions, mm	1,000 X 4,660 X 1,300
Weight, kg	3,600

The automated machine is being installed at the Melitopol Motor Plant.

It was developed and manufactured by the NIITavtoprom NPO.

The model LA 45 line is used to assemble the cylinder heads of internal combustion engines. The line is distinguished by an optical-electronic device for monitoring

the flatness of the gas-joint ring. It is operated by a freely programmable controller designed by the MKTEIavtoprom [expansion unknown].

#### Technical Data of Model LA 45 Line

Productivity, units/h	86
Cycle time, s	42
Number of working positions including:	22
automated positions	16
manual positions	5
reserve positions	1
Installed power rating, kW	23
Overall dimensions, mm	39,950 X 5,780 X 2,660
Weight, kg	29,970

The line is operated by a crew of six. It is being installed at the Avtodorizel Production Association's Tutayev plant. It was developed by the MKTEIavtoprom and manufactured by MKTEIavtoprom's experimental plant Avtopromsborka NPO.

The equipment set for assembling the stators of the G-290 generators includes a semiautomatic machine 1MK-682 and a 1AP-745 unit.

The 1MK-682 semiautomatic machine is used to insulate the multi-slot generator stators, the slots of which can be straight or skewed up to 15° (0.2-0.4 mm thick electrical insulation cardboard or plastic are used as insulating materials). It consists of a welded housing, a roller-type spinneret mechanism, mechanisms for pushing through insulation, turning and shifting the drum, and step-wise feed, as well as of a roll holder, a pneumatic cylinder for moving the carriage, and a drive.

The semiautomatic machine is of the right-hand and left-hand design and it can operate in either the right-hand or the left-hand mode or in both modes simultaneously, depending on the program.

#### Technical Data of Semiautomatic Machine 1MK-682

Productivity, units/h	60.0
Power rating, kW	1.9
Power-supply voltage, V	380.0
Frequency, Hz	50.0
Air pressure, MPa	0.4
Overall dimensions, m	1.5 X 1.5 X 1.5
Weight, kg	1,700.0

Unit 1AP-745 is used for sizing the slot insulation of the generator stators. It is in the form of a welded pedestal with the sizing mechanism and pneumatic equipment mounted on it.

**Technical Data of the 1AP-745 Unit**

Productivity, units/h	60.0
Cylinder travel, mm	100.0
Maximum force, kN (kgs)	18.0 (1,800)
Overall dimensions, m	0.7 X 0.8 X 1
Weight, kg	300.0

The 1MK-682 semiautomatic machine and the 1AP-745 machine are being installed at the Kuybyshev Automobile-and-Tractor Electrical Equipment Plant imeni A. M. Tarasov (KZATE). An economic effect of 18,000 rubles a year is expected.

The machines were developed by the NIIAE [expansion unknown] and manufactured by KZATE.

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UDC [621.791.76.052:621.7.044.2]:669.71:620.193.41

**Corrosion Resistance of Welded Aluminum Joints After Explosive Cladding**

*18420122a Kiev AVTOMATICHESKAYA SVARKA in Russian No 1, Jan 89 (manuscript received 18 Jun 87, in final version 29 Sep 87) pp 21-24*

[Article by V. G. Petushkov, doctor of technical sciences, M. I. Zотов, candidate of technical sciences, and S. G. Polyakov, candidate of technical sciences, Electric Welding Institute imeni Ye. O. Paton, UkrSSR Academy of Sciences, A. N. Kuzyukov, candidate of technical sciences, and L. V. Zaytseva, engineer, Ukrainian Scientific-Research and Design Institute of Chemical Machine-Building, Severodonetsk]

[Abstract] The problem of predicting the effectiveness of explosive cladding of welded aluminum joints for protection against corrosion is considered, equipment made of A85 commercially pure aluminum being used for production of nitric acid. A durability criterion for such joints is established on the basis of laboratory experiments and theoretical analysis. The corrosion process was studied under conditions simulating the key stages of the  $\text{HNO}_3$  production process, namely in aqueous solution with 50 pct  $\text{HNO}_3$  at 80 °C and with 98 pct  $\text{HNO}_3$  at 70°C. Potentiodynamic polarization curves were plotted with a P-5827M potentiostat at a sweep rate of 600 mV/h. The depth of crevice corrosion in a welding seam was measured over a period of 8 hours and then monitored under a microscope over a period of 1000 hours, seams with wavy contact surface being of particular concern and the corrosion kinetics during cathodic polarization being particularly critical. The crevice depth was in this case found to increase monotonically while it was found to peak out and then decrease during anodic polarization. This trend is explained by electrochemical nonhomogeneity of the material at the contact surface with an attendant nonuniform potential distribution and by absence of gaseous

corrosion products preventing direct access of the aggressive medium to crevices. Shift of the potential into the cathodic range slows down corrosion of the cladding material while shift of the potential into the anodic range speeds it up. The rate at which a crevice deepens remains almost constant in both cases, however, owing to the intricacy of the contact geometry. Access to a crevice is also closed by solid corrosion products filling it during anodic polarization but not during cathodic polarization. The results of this study can be used in design and construction of autoclaves. References 5: 4 Russian, 1 Western.

UDC [621.791.77.052.08:778.38]:621.643:669.141.24

**Use of Holographic Interferometry for Nondestructive Quality Control of Welded Parts**

*18420122b Kiev AVTOMATICHESKAYA SVARKA in Russian No 1, Jan 89 (manuscript received 17 Jun 87, in final version 1 Sep 87) pp 38-40, 43*

[Article by L. M. Lobanov, doctor of technical sciences, V. A. Pivtorak, candidate of physical and mathematical sciences, G. I. Tkachuk, engineer, and R. V. Tomashevskiy, engineer, Electric Welding Institute imeni Ye. O. Paton, UkrSSR Academy of Sciences]

[Abstract] Holographic interferometry as a method of non-destructive flaw detection was experimentally tested for reliability and sensitivity on tubes with welding seams and on plates with protective coatings. The optical system of a UIG-2M interferometer using an LG-38 He-Ne laser was laid out for recording off-axis Leith-Upatiniex holograms on 8E75 "Agfa-Gevaert" photographic plates with 3000 lines/mm resolution. Tubes made of grade-3 carbon steel with helical seams, inside diameter 90 mm and wall thickness 12 mm, were optimally stressed by heating or internal pressure so as to ensure detectability of displacement and strain differences. For reference and comparison, seamless tubes were also inspected and the distortion of elliptical interference fringes under load by a welding seam was analyzed. Plates of grade-3 carbon steel 120 mm wide and 200 mm long with 0.1 mm thick protective ceramic coating were inspected, after having been heated to 60°C sufficient for excessive expansion of the coating, and areas of coating separation from the base metal were indeed detected. References 3: 1 Russian, 2 Western (both in Russian translation).

UDC 621.791.75:[621.865.8-529:681.513.6]

**Adaptation of Drives of Welding Robot to Varying Loads**

*18420122c Kiev AVTOMATICHESKAYA SVARKA in Russian No 1, Jan 89 (manuscript received 26 May 87, in final version 3 Mar 88) pp 41-43*

[Article by F. N. Kisilevskiy, doctor of technical sciences, K. Kh. Zelenskiy, candidate of technical sciences, and A. V. Naydek, engineer, Electric Welding Institute imeni Ye. O. Paton, UkrSSR Academy of Sciences]

[Abstract] Adaptive dynamic tuning of an anthropomorphic welding robot and its drives for operation under

varying loads is proposed, considering specifically a robot driven by a separately excited direct-current motor through an elastic reducing gear set. The algorithm for such tuning is based on the equations of manipulator dynamics, assuming a conventional kinematic scheme of the manipulator and taking into account its geometrical characteristics and mass-inertia parameters. The effectiveness of dynamic tuning of the control system parameters is evaluated for a TUR-10 welding robot with the motor time constant within the 0.048-0.197 s range and with the control system "rigidly" tuned to a specific magnitude of that time constant. Dynamic tuning is in this case shown to reduce overregulation from 75 pct to 10 pct. References 3: all Russian.

UDC [621.791.72:621.373.826].003.13

#### Dependence of Welding Production Cost on Parameters of Laser Welding Process

18420122d Kiev AVTOMATICHESKAYA SVARKA in Russian No 1, Jan 89 (manuscript received 24 Apr 87, in final version 6 Jul 87) pp 67-70

[Article by V. V. Glukhov, doctor of economic sciences and I. P. Gvozdeva, engineer, Leningrad Polytechnical Institute imeni M. L. Kalinin]

[Abstract] A cost analysis of laser welding is made, an LT1-2 continuous-wave electric discharge 5 kW CO<sub>2</sub>-laser with a closed gasdynamic loop for welding titanium alloys being selected as an illustrative example. The mathematical model describing the dependence of the production cost on laser parameters is based on the premise that the cost of a welding seam depends principally on the laser radiation intensity, the practical lower and upper limits of this parameter being 0.1-0.2 MW/cm<sup>2</sup> respectively. Two other relevant variable factors are laser beam diameter and supplementary welding time, the required fusion depth being a design factor. The production cost is broken down into energy costs associated with supplying He, CO<sub>2</sub>, N<sub>2</sub>, water and cost of electric energy, the basic labor wage, amortization allowance, repair and maintenance costs and shop expenditures. Two not laser-related factors influencing the production cost are also included in the model, namely the auxiliary equipment to main equipment cost ratio and the equipment workload ratio. In regard to the latter, calculations have been made for single-shift, double-shift, and triple-shift shop operations. References 4: all Russian.

UDC 621.791.72/.75:536.14.001.24

#### Characteristics of Metal Heating During Welding With Laser Beam and Electric Arc

18420122e Kiev AVTOMATICHESKAYA SVARKA in Russian No 1, Jan 89 (manuscript received 25 Dec 87) pp 73-74

[Article by S. G. Gornyy, candidate of technical sciences, and V. A. Lopota, candidate of technical sciences, Leningrad Polytechnical Institute imeni M. I. Kalinin, V. D. Redozubov, engineer and V. S. Smirnov, candidate of technical sciences, All-Union Scientific Research Institute of Electric Welding Equipment]

[Abstract] Heating of the parent metal during combined laser-beam and electric-arc welding is analyzed for effi-

ciency on the basis of an experiment with an RS-1000 welding CO<sub>2</sub>-laser and a UPS-301 arc welder using tungsten electrodes 2 mm in diameter for welding 08Cr18Ni10Ti steel. Helium was used for the gaseous shield and the polarity of the arc remained forward throughout the experiment. Welding was done with the arc ahead of the laser beam and with the arc behind the laser beam, the arc current being varied over the 15-120 A range and the laser power being varied over the 100-1000 W range. The total thermal efficiency, dependent on the interaction of the two heat sources and its range limited by the law of energy conservation, is found to be maximizable for any given welding speed by proper matching of the arc current and the laser power. The maximum allowable welding speed is found to increase monotonically with increasing total power while it peaks at some arc power when welding is done with an electric arc only. For combined welding, therefore, the laser power should be not lower than the arc power. References 5: 4 Russian, 1 Western (in Russian translation).

UDC 621.791.927.2:621.373.826

#### Laser-Powder Surfacing of Various Fractions of Self-Fluxing Powders

18420106a Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 12, Dec 88 pp 2-3

[Article by S. G. Gornyy, candidate of technical sciences, A. K. Lozovoy, engineer, Leningrad Polytechnical Institute imeni M. I. Kalinin, N. N. Odintsov, engineer, L. A. Shternin, candidate of technical sciences, All-Union Electric Welding Equipment Scientific Research Institute]

[Abstract] A study is made of the influence of the particle size of powders on the technological parameters of surfacing by means of a scanning laser device. Studies were performed with a Spectra Physics type M 973 installation using a special scanning system yielding uniform distribution of radiant energy over width of 10 mm. Powder was deposited onto the substrate so that the depth of the deposited layer increased uniformly to 7 mm over a specimen with a length of 145 mm and width of 30 mm. Specimens were treated with laser radiation with a power of 2 kW at a substrate movement speed of 2 mm/s. It is found that in the process of laser-powder surfacing, the surfacing factor is greatest when powders of smaller particle diameters are used. The surfacing factor should be greater when surfacing is performed on a deposited layer of powder than when the powder is blown onto the substrate during the surfacing process. References 4: all Russian.

UDC 621.791.3.072

#### Manufacture of Powdered Composite Solders

18420106b Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 12, Dec 88 pp 16-17

[Article by Candidate of Technical Sciences I. P. Chekunov]

[Abstract] Composite solders type 5AN, 5VA and 6MA, based on type 5A solder plus fillers consisting of powdered

Kh18N15 steel, tungsten and molybdenum respectively, were studied. The components of the solders were mixed in a ball mill for 5-8 hours and tested as to pressing properties. Rings were manufactured by cold closed die forging. This method was highly productive and operated without waste. Introduction of this method could save money by reducing the wasting of solder. References 2: both Russian.

UDC 621.791.75.042

### High-Strength Welding Wire for Welding Dissimilar Steels

18420106c Moscow SVAROCHNOYE  
*PROIZVODSTVO* in Russian No 12, Dec 88 p 18

[Article by V. Ye. Lazko and M. T. Borisov, candidates of technical sciences]

[Abstract] To produce high-strength joints in dissimilar steels, the seam metal must combine the properties of austenitic and martensitic structures. This is achieved by using a transition-type welding wire (Sv-06Kh13N6K8M4B), which minimizes the hard transition zone with type 30KhGSN2A steel. One distinguishing characteristic of this wire is that it contains 8 percent Co, assuring optimal mechanical properties and excellent cold-crack resistance of joints. Production of the new wire (type EK-43) has now been started. It allows the strength properties of joints to be increased by 50 percent in comparison to joints produced by austenitic wire.

UDC 621.791.4.05:539.738.3:669.295+669.15.194.56/  
57:539.4

### Influence of Initial Material Composition on Formation and Properties of Welded Spot Joints of Titanium Alloys With Steel and Nickel

18420107a Moscow SVAROCHNOYE  
*PROIZVODSTVO* in Russian No 11, Nov 88 pp 15-17

[Article by O. G. Bykovskiy, candidate of technical sciences, I. V. Pinkovskiy, candidate of technical sciences, S. N. Minaylo, engineer, Zaporozhye Machine-Building Institute imeni V. Ya. Chubar, V. R. Ryabov, doctor of technical sciences, Electric Welding Institute imeni Ye. O. Paton and O. A. Magnitskiy, engineer, Moscow Petrochemical and Gas Industry Institute imeni I. M. Gubkin]

[Abstract] A study was made of the formation of welded joints of steels and nickel with titanium alloys, and of the relationship between the structure and composition of intermediate layers and the strength characteristics of the spot welds. The materials tested were welded at the optimal welding parameters for each combination of materials, the spot welds produced were tensile tested and bend tested. The strength characteristics of the joints formed were found to be determined by the nature of the

bonds created between the welded metals in the transition zone. Joints formed in the liquid-solid phase through a thin deformed diffusion intermediate layer with a limited quantity of residual melted core metal were strongest. Relief contact welding with artificial internal splattering can produce joints with the desired levels of serviceability. References 6: 5 Russian, 1 Western.

UDC 621.791.3:669.295+669.715

### Reaction of Titanium With Aluminum Solder

18420107b Moscow SVAROCHNOYE  
*PROIZVODSTVO* in Russian No 11, Nov 88 pp 33-35

[Article by A. F. Nesterov, candidate of technical sciences, and G. V. Studenov, engineer, Moscow Aviation Technological Institute imeni K. E. Tsiolkovskiy]

[Abstract] The influence of temperature-time parameters on intermetallide growth kinetics is studied under conditions imitating vacuum soldering of lap joints of VT1-00 titanium alloy using type A5 aluminum solder. The results are used to suggest an experimental-computational method to determine mode parameters for which the intermetallide layer formed does not reduce the strength of the solder joint. In all cases, there was an incubation period followed by a period of intermetallic phase growth, followed by a period of no growth, followed finally by a period of resumed intermetallic layer growth. References 3: 2 Russian, 1 Western.

UDC [621.791.053:620.18]:669.14.018.44:620.191.33

### Formation and Development of Cracks in Welded Joints in Heat-Resistant Steels

18420057a Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 88 (*manuscript received 20 Jan 87; in final form 23 Jun 87*) pp 5-9

[Article by R. Z. Shron, doctor of technical sciences, L. E. Krechet, N. I. Nikanorova, and I. F. Nebesova, engineers, Urals Affiliate, All-Union Heat Engineering Scientific Research Institute imeni F. E. Dzerzhinskiy]

[Abstract] A study is made of some peculiarities of the formation and development of cracks related to the metal structure in welded joints of heat-resistant steels. The joints were made by electrodes similar in chemical composition to the base metal. It was found for all of the types of damage studied that the grain boundaries of the final structure coincided with those of the initial structure. This agreement and the related harmful influence of segregations which intensively contaminated high-temperature boundaries resulted in a decrease in resistance to fracture between grains, causing selective fracture resistance in the seam metal. Elimination or reduction of structural heredity effects in  $\delta$  to  $\gamma$  and  $\gamma$ - $\alpha$ - $\gamma$  conversions by optimizing alloying of the seam metal and welding and heat treatment parameters is therefore

important as a method of increasing the resistance to fracture between grains in the seams. References 6: all Russian.

UDC [621.791.754'291.052:669.292]:669.787:620.18

### Influence of Oxygen on Structure and Properties of Vanadium Welded Joints

18420057b Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 88 (manuscript received 15 Jan 87; in final form 1 Jul 87) pp 13-16

[Article by A. D. Demchenko, candidate of technical sciences, and M. M. Nerodenko, doctor of technical sciences, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] A study is made of the interaction of the oxygen of the welding atmosphere with the seam metal and the influence of oxygen on the mechanical properties of vanadium welded joints is determined. Studies were performed on unalloyed type VNM-1 vanadium in the deformed state using specimens 1 mm thick. Impurity content was, in percent: O 0.002, N 0.002, H 0.0001. Specimens measuring 200 $\times$ 60 $\times$ 1 mm were welded at 112 $\cdot$ 10 $^4$ m/s on an arc-welding machine in an atmosphere of helium following evacuation of the chamber to 1.33 $\cdot$ 10 $^{-3}$ Pa. The mechanical properties of the welded joints were studied by determining the static bending and tensile strength and impact toughness. It was found that an oxygen content of over 1 $\cdot$ 10 $^{-2}$  percent in the helium caused intensive saturation of the seam metal, forming finely dispersed vanadium oxide inclusions and significantly increasing the oxygen content in the solid solution. Oxygen at over 1 $\cdot$ 10 $^{-2}$  percent greatly reduces the strength, ductility and impact toughness of the seam metal. References 7: all Russian.

UDC 621.791.754'293:669.15'786-194.046.517

### Kinetics of Denitrogenation of Metal During Welding of High-Nitrogen Steels

18420057c Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 88 (manuscript received 23 Apr 87) pp 17-23

[Article by K. A. Yushchenko, doctor of technical sciences, N. P. Kazennov, engineer, A. M. Solokha, Yu. M. Pomarin, and N. N. Kalinyuk, candidates of technical sciences, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Science]

[Abstract] Denitrogenation conditions, given simultaneous reduction of pore-formation probability in the welded seams of austenitic steels in which the nitrogen concentration is above equilibrium, are studied. Seams were made by argon-arc welding with nonconsumable electrodes. Experiments were performed on an installation for melting of specimens in the suspended state in a magnetic field. It was found that degassing of melted metal with nitrogen content above the equilibrium level occurs in two stages, with bubble liberation of nitrogen occurring

in the first second, followed by diffusion liberation. A slag film present on the surface of a liquid metal drop decreases its reaction surface and increases the thickness of the diffusion layer, reducing the mass transfer of nitrogen. The denitrogenation rate is proportional to the supersaturation relative to the equilibrium concentration. It is much greater (by 8-12 times) during the first two seconds of the existence of a supersaturated melt. References 17: 13 Russian, 4 Western.

UDC [621.791.75.011:669.14.018.29]:620.18

### Thermally Hardened Vst3 Steel for Welded Structures

18420057d Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 88 (manuscript received 23 Apr 87; in final form 29 Jun 87) pp 51-55

[Article by V. I. Trufyakov, corresponding member, Ukrainian Academy of Sciences, M. N. Chalenko, engineer, A. V. Babayev, G. V. Zhemchuzhnikov and G. A. Ivashchenko, candidates of technical sciences, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences, and V. I. Spivakov, candidate of technical sciences, Institute of Ferrous Metallurgy, USSR Ministry of Ferrous Metallurgy]

[Abstract] The service properties of thermally hardened VSt3sp steel were studied on 10-20 mm thick rolled sheets, hardened by "interrupted" hardening. Specimens with 0.15-0.21 percent carbon were selected for study. Metallographic studies showed structural heterogeneity throughout the entire thickness of the hardened steel sheets. The mechanical properties were determined using standard test specimens. Fracture ductility was estimated using the deformation criterion. Weldability was determined by standard methods taking into account the influence of mechanical and structural heterogeneity resulting from both hardening and from welding. The resistance of the seam metal to the formation of hot cracks was studied. It was found that the material can be welded under normal conditions with materials normally used for low-carbon steels of its strength class. Optimal welding energy was 12-34 kJ/cm for 10-12 mm thick steel. Specimens 20 mm thick required up to 40 kJ/cm. Thermal hardening significantly improves the cold resistance of the steel without influencing the fatigue strength. The material is recommended for welded structures used at temperatures down to -40°C. References 9: 6 Russian, 3 Western.

UDC 621.791.75.052:669.14.018.8:620.193.002.235

### Welding of Type 02Kh8N22S6 Steel With Rapid Cooling

18420057e Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 88 (manuscript received 2 Dec 86) pp 56-59

[Article by V. Yu. Skulskiy, V. P. Loginov, engineers, V. N. Lipodaiyev, and V. I. Pavlovskiy, candidates of technical sciences, Ye. P. Los and N. I. Savoley, engineers, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] Rapid cooling of type 02Kh8N22S6 steel after welding can reduce or eliminate the formation of intergrain segregations, thus preventing intercrystalline

corrosion. One effective means of cooling is application of a paste based on water-containing clay or easily decomposable mineral salts containing water of crystallization. This article discusses the influence of such pastes when applied before or during welding on the corrosion properties of the material near the welded joint. The salt paste was found most effective in cooling the seam and the zone of thermal influence. Intercrystalline corrosion was not seen in specimens welded with rapid cooling by the salt paste. This eliminates the need for heat treatment of the welded joints after welding. References 6: all Russian.

UDC 621.791.72.052:621.373.826:669.14.018:620.18

#### Laser Welding of Ferritic Stainless Steels

18420057f Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 88 (manuscript received 9 Sep 86; in final form 5 Jan 87) pp 60-62

[Article by K. A. Yushchenko, doctor of technical sciences, M. V. Meshkov and A. M. Korol, engineers, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] A study is made of the weldability of 3 mm thick OKh18T1 steel and 2 mm thick Kh25T steel, as well as of the influence of laser welding technology and conditions on the quality of joints produced and their mechanical properties. Experiments were performed on a type Ob-2243 laser welding installation developed at the authors' institute, operating in the 1-2.4 kW power range. A 180 mm focusing lens produced a focal spot 0.35 mm in diameter, specific power in the focal spot being 1-2.4 MW/cm<sup>2</sup>. Laser welding required high quality assembly of the elements to be joined. At 40 m/hr, edges must be positioned to within 0.6 mm, and at 180 m/hr, the edges must be positioned to within 0.3 mm to avoid gaps in the root of the seam. Rolling scale on the surface of specimens requires that the welding speed be reduced by about 25 percent in comparison to scale-free specimens, but does not disrupt the stability of the welding process. Argon and a helium-based gas mixture were used to protect the welding bath and seam root. The welding speed has a great influence on ductility and impact toughness. Increasing speed decreases the welding bath size and the time the metal is melted, increasing crystallization rate and yielding a more homogeneous small-dendrite structure, decreasing chemical heterogeneity and increasing impact toughness and ductility. References 8: all Russian.

UDC [621.791.75.052:669.15-194]:621.7.044.2

#### Explosion Treatment of Welded Joints in Low-Carbon Steel Before Heat Treatment

18420057g Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 88 (manuscript received 22 Dec 86; in final form 16 Oct 87) pp 68-69

[Article by V. G. Petushkov, doctor of technical sciences, Yu. I. Fadeenko, candidate of physical-mathematical sciences, S. N. Smirnova, and A. I. Grishayenko, engineers, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] The possibility of performing heat treatment at lower temperatures and for a shorter time following

preliminary explosion treatment of welded joints produced with low-alloy welding materials is studied. Studies were performed on welded joints in type Kh70 steel with a seam metal chemical composition, in percent: C 0.1, Si 0.31, Mn 1.8; base metal composition: C 0.05, Si 0.28, Mn 1.6, P 0.02, S 0.003, Nb 0.06, Ti 0.02, B 0.001, Mo 0.01. Explosion treatment was performed by cord and strip charges applied to the surface with a running mass of 12 g/m and detonation velocity of 6500-7500 m/s, after which the specimens were placed in a furnace heated to the assigned temperature, held for 40 minutes and then cooled in air. Following explosion treatment, heat treatment significantly increases the yield point even at high-tempering temperatures of 600-700°C. Explosion treatment reduces the maximum heat treatment temperature required to about 850°C and time to 40 minutes, significantly increasing the yield point in comparison to heat treatment without explosion treatment. References 9: 8 Russian, 1 Western.

UDC 621.791.16:621.315.616-427.47

#### Variation of Wire Insulation Dielectric Strength With Ultrasonic Welding Conditions

18420057h Kiev AVTOMATICHESKAYA SVARKA in Russian No 7, Jul 88 (manuscript received 4 Nov 86) pp 70-72

[Article by B. Ya. Chernyak and B. E. Frenkel, candidates of technical sciences, V. A. Bokov, engineer, Tashkent Motor Vehicles and Roads Institute, G. N. Korob and L. I. Bezruk, candidates of technical sciences, and G. B. Yesaulenko, candidate of chemical sciences, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] This work is dedicated to determining the optimal conditions for ultrasonic welding assuring high dielectric strength of the insulation as well as to a study of its influence on the morphology of polymer insulation repaired by ultrasonic welding. Studies were performed on type KPBP cable designed to operate at 3300 V. Experiments on the ultrasonic welding repair of insulation were performed on a press-type ultrasonic installation with energy applied to the product from both sides. The quality of repair was evaluated based on the breakdown voltage applied between the copper core of the cable and a current-conducting liquid in which the cable was placed. Welding was performed under constant pressure of 2.5 MPa with oscillating amplitudes of the vibrating head of the waveguide of 10, 20 and 30 μm. Increasing the amplitude was found to decrease the dielectric strength of the restored insulation due to the variety of morphologic damage done to the low-pressure heat-stabilized polyethylene by the vibrating head. References 5: 4 Russian, 1 Western (in Russian translation).

**Corruption Allegedly Continues in Gold Artels**  
*18420014 Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 31 Aug 88 pp 3-4*

[Article by Yu. Petrov: "It's Time To Separate the Gold From the Ore"]

[Text] The collegium of the Main Administration of Precious Metals and Diamond of the USSR Council of Ministers [Glavalmazzoloto SSSR] has discussed the progress in implementing the CPSU Central Committee decree entitled "On the Article 'No, You're Not Dreaming'" published in SOTSIALISTICHESKAYA INDUSTRIYA on 13 May 1987."

"This is the second time in the last seven months that we are discussing this problem," said V. Rudakov, head of Glavalmazzoloto. "All associations have reported that the deficiencies mentioned in the central committee decree basically have been eliminated. While we have produced a lot of paper, what is the result of all this?"

**Fact From the Stenographer's Record**

An inspection carried out in June at the Severovostokzoloto, Yakutzoloto and Amurzoloto associations showed that there still had been no fundamental breakthrough in the effort to eliminate deficiencies and distortions in the activities of the gold-production artels.

V. Chupin, the deputy head of the production administration, reached the same conclusion, which was also contained in the inspection report, the collegium decree and V. Rudakov's opening remarks. In other words, those serious deficiencies which were disclosed by this newspaper and which were noted in the CPSU Central Committee decree continue to plague the artels. Why?

Before answering that question, let's first recall what the article "No, You're Not Dreaming!" was about. This is all the more necessary since writers in several popular publications are still turning things upside down, interpreting the article differently than the CPSU Central Committee decree does. Some of these writers have gone to absurd lengths, saying that the article is absolutely true, but the facts in it are wrong. The goals of this "spontaneous activity" is clear as day: to clean up the professional images besmirched by these artels; to dump the blame and responsibility off on others and to obscure the essence of these problems, which are so acute and scandalous that they are discrediting a very progressive form of the cooperative movement. These writers want to put the too bold journalists in their place and to show them the boundaries of glasnost, which they have taken it upon themselves to establish. They prefer an accusatory style of writing, and they produce anything but elegant literature.

You will recall that the article analyzed the sources of the following negative phenomena in several gold-production artels: rapacious mining of deposits, gold thefts,

bribery, corruption, criminal activity and unpardonable infringements on artel democracy. The chairmen of these artels have usurped power and have surrounded themselves with toadies, relatives and acquaintances who are beholden to them.

The article called for the removal of these moss-covered relics of the stagnant years, which are blocking the road of modern cooperation. It advocated giving the artels every chance to exhibit the advantages of this progressive form of labor organization. It advocated putting a firm stop to thefts of gold, which is public property.

The CPSU Central Committee noted in its decree that "the article 'No, You're Not Dreaming!' was correct in raising questions about serious deficiencies in the operational organization of gold-production artels," and that "the newspaper's critical remarks were aimed not at discrediting the artels, but at eliminating distortions in the operation of this cooperative form of labor organization."

We stated above what these distortions are. They were the subject of the meeting of the Glavalmazzoloto collegium. Passions flared mainly during discussion of the key problems with these labor collectives. What exactly were these problems? The CPSU Central Committee decree states them precisely.

"Frequently, the artels are assigned more favorable deposits than those given to state-run organizations. In many of these areas, environmental laws are broken during mining. Established mining procedures are flagrantly violated, resulting in excessive metal losses. A number of artels continue to allow flagrant violations of financial and economic discipline and of the democratic principles of self-management. Civil rights are being trampled. Gold-producing organizations, particularly the artels, have not established the necessary conditions for preventing gold thefts, embezzlement or misconduct."

The decree also pointed out serious breaches of personnel policy in the makeup of artel collectives, especially at the management level.

Finally it came time to report to the CPSU Central Committee on how the decree is being fulfilled, to report the results of investigations and to find the reasons for these problems.

**Fact From the Stenographer's Record**

In many places, gold mining practices are in serious violation of approved production technology and environmental laws. For example, monitoring agencies stopped gold-mining operations of the Severovostokzoloto and Yakutzoloto Associations 30 times during 1987. The Association Artel of Aldanzoloto Combine alone caused more than 100,000 R of environmental damage through water pollution.

When the natural desire to be wealthy becomes an abnormal impulse to get rich at any cost, then the framework of the law can seem stifling. Good people who fall under the influence of self-seekers can become plunderers.

Last year, it became clear toward the end of the season that one of the artels of Lenzoloto would not make its planned profit. This would mean that the daily pay rate would not be as high as originally planned. Suddenly, the improbable happened: the artel in the end reported that it had fulfilled the plan, had produced above-plan metal, had made the planned profit and had fulfilled all the other indicators. In addition, the artel received a hefty bonus of several hundred thousand rubles.

What happened?

"We checked," said V. Makarov, general director of Lenzoloto Association, "and found that the artel, without any permission, had dug into a rich deposit assigned to a state-run enterprise."

"Were they punished?"

"Punished? The artel managers were fined 50-70 R apiece. But they receive bonuses of several thousand rubles."

"You should punish them to the full extent of the law for this banditry," insisted V. Rudakov. "You have full authority."

"I have no authority," responded Makarov.

"Cancel the basic agreement on the grounds of unlawful encroachment on the deposit. Confiscate all the metal produced there and transfer the case to the proper authorities."

"The case was turned over to the procurator's office, but they returned it."

Makarov's announcement brought the audience to life and provoked sharp comments. Now that democracy is expanding in many areas, including economics, and now that important rights are being given to labor collectives, especially cooperatives, how can you defend state interests while avoiding the notorious policy of administration by fiat? However, on the other hand, wouldn't you say that four unauthorized encroachments on deposits by artels in one season represent an extraordinary event of state importance? After all, this isn't clay or limestone, but gold which is being seized, and the government has a monopoly on gold. Everyone would agree that this is clearly a criminal act. But what about the procurator's office? Don't they see any violation of the law in this? Or don't they want to see?

But listen how Makarov continues:

"Today, the artel chairman is getting further and further away from the oversight of the association in which the

artel operates and with which it has financial ties. Earlier, the chairman handled inspectors' reports on violations deferentially; now he frequently pigeonholes them."

"Why is this?" Makarov asked himself, and then answered his own question: "The local authorities are now supporting him, and are beginning to take him under their wing more often. In return, the chairman does some things for them and, it must be said, he does these things willingly. When I try to reign him in, he seeks their protection and gets it."

"We support you on this," interrupted V. Rudakov, "you have the control, as well as the responsibility. The local authorities will not hide financial violations."

"Just cancel the artel's contract and that will be that," said someone from the audience.

"But," parried Makarov, "how am I supposed to cancel the artel's contract if it produces the planned amount of gold? Then it's my responsibility to produce the gold."

"That's right."

Of course, this meeting might have had a different, more modern, tone. What I mean is that it might have analyzed how and why the economic levers are failing to work (or are working poorly) in the relationships between state enterprises and artels.

For example, one artel refused to sign an agreement until the association transferred all equipment to it for free. This fact was noted, but no thorough evaluation was offered as to whether it was good or bad, a progressive phenomenon or extortion. Why did the head of Indigizoloto Combine even bring it up? So that later on he could say that he told us so? Or was he sharing advanced experience with us?

A very important question is the ecological consequences of the activities of these gold-production artels. Many of them, as has been repeatedly noted, leave a barren lunar landscape behind them. If you consider that gold-production artels operate mainly in climatic zones where the environment is easily damaged, and where the effects of these injuries are felt for decades or possibly forever, then any measures taken against these violators would not seem overly harsh. But in fact what has happened?

Not a single chairman or artel has been found criminally responsible for environmental destruction. No one is being brought to justice now either. Does this mean that there are no grounds for doing this? Absolutely not.

The artels have not spared anything in their pursuit of "profitable" gold: not fish spawning areas, not historical

artifacts nor thousands of hectares of land now disfigured to the point of permanent barrenness. The dismal Pechora Artel was working away merrily on the protected Kozhym River, and in the process destroyed spawning areas not only for salmon, but also for other rare fish listed in the RSFSR Red Book. Scientists investigating the consequences of this "efficient" operation expressed the loss in terms of rubles: a minimum of 1.6 million per year. Where should the money come from to make good this loss: from the artel's income, from the government or from future generations? For example, the procurator's office didn't get reimbursement from anyone: the artel paid a fine, and that was it. And who will pay for the damage caused when a bulldozer eradicated priceless archaeological relics, including major neolithic sites?

Nowadays we have democracy, say the procurators, throwing up their hands in despair. These are the same people who are used to checking themselves and evaluating their own actions. No, they say, there is no corpus delicti in these actions.

It would appear that these servants of the law are being disingenuous. The law cannot protect these "manifestations of democracy" designed to enrich a group of people through the barbaric exploitation of the environment, which is public property.

#### Fact From the Stenographer's Record

In the 1986 season, 13 fatal accidents occurred in the artels, while in 1987, this number nearly doubled to over 20 accidents.

What are the root causes of these tragic statistics? Unfortunately, not a single one of these sorry facts was thoroughly analyzed at the meeting. These stark figures were casually mentioned, and the directors of the gold-production associations and enterprises avoided them in their speeches. Can it be that these people, who have power and enormous responsibility and who have stolen millions of rubles in gold, don't value human life more than a nickel? Or is it that the deaths of 21 artel workers aren't anything scandalous, aren't anything for which the bells should toll? However, these people are dying in the prime of life; these are the only type of people that you find working as placer miners, who undergo a tougher selection process than cosmonauts. Why is there silence about this?

No, the directors of gold-production associations and enterprises are the same kinds of people as you and I. They're familiar with all human experiences: sadness, rage and the pain resulting from irretrievable losses. They're apparently also familiar with the desire to fulfill plans, even at any cost.

After the article "No, You're Not Dreaming!", several writers and broadcasters attempted to prove that these artel workers are efficient because they work of their own volition from dawn to dusk. Every one of them interprets this fact the same way: we all should work like that. As a

result, the production costs for gold artels are lower, and fewer workers are required. Thus, productivity is higher than at state-run enterprises.

I won't undertake to agree or disagree with this. The Glavalmazzoloto collegium heard examples of well-run artels, as well as artels that had to be disbanded because of poor returns or constant violations. Although it was only hinted at, the true cause of the increasing number of tragedies was brought to light: the excessive intensification of labor, which goes beyond the bounds of all norms and laws.

Let's draw a picture of this for ourselves. It's getting near the end of the season, and things aren't going particularly well at an artel. The chairman (it is namely the chairman, not the artel management, as was noted at the meeting, who has become an arbitrary administrator with unlimited, almost dictatorial powers) decides to put the artel on a shock-work schedule: 14 hours on, 10 hours off. These working hours, by the way, are considered the norm nearly everywhere. But let's be realistic: after working a 14-hour shift, a truck driver, with eyes aching so badly that he can't close them, will have to take half a bottle of sleeping pills just to unwind and get to sleep. You have to get to sleep fast, since you have only 10 hours before another 14-hour turn driving over ruts and potholes.

The next morning, with his head still buzzing, the driver gets into his truck. By the end of the shift, the accumulated fatigue reaches the limit, but he still has to take home the other people on the shift, who are also exhausted to the limit by their 14-hour "labor watch." Somewhere on a steep, washed-out turn, the driver doesn't react quickly enough to some hazard.

People are dying for other reasons as well. But this is the basic principle: people are dying either at the end of their shifts or on the way home from work.

"Yes, there is only one solution: cut down these long shifts," said someone in the audience.

The reply to this was that the artels would require more workers.

"So let them increase the number of workers," came the response from the audience.

This proposal provoked no commentary, for not one artel will go along with that. They won't go along with it because all their economic indicators, including wages, would drop in that case. So this is it: the high wages in artels are always the result of overwork with the accompanying threat to health, and even to life.

#### Fact From the Stenographer's Record

Democratic principles involving the life and work of gold-artel collectives are being violated quite often, especially in Amurzoloto Association. These principles aren't

being violated by the state-run enterprises or the local agencies, but by the artel managements themselves.

Of the many responses received by SOTSIALISTICHESKAYA INDUSTRIYA after publication of "No, You're Not Dreaming!" and other discussions on this subject, the most troubling are the letters from the artels. Everything would be all right, say the artel workers, if it weren't for the coercion by the artel managers, the suppression of all freedoms, the requisitions and fines, the humiliations and the total defenselessness against arbitrary rule. Some genius decided that the labor laws don't apply to artel workers, and the courts often do not take it upon themselves to defend the workers' interests.

"The bulk of complaints from the artels," said V. Rudakov indignantly, "concern the poor treatment of artel workers. Even pregnant women and young mothers are treated badly."

This so-called artel democracy has nothing to do with the lawful government which we are talking about so seriously now.

A. Melnikov, an executive in the USSR Procurator's Office, was enraged when he told the meeting that "in the majority of artels, the democratic principles of collective life are violated in the crudest manner. Artel chairmen have actually usurped power. But the most surprising thing is that people aren't complaining about this! Everything revolves around the ruble, and is held in place by the ruble."

The article "No, You're Not Dreaming!" and subsequent publications gave good illustrations of how everything is held in place by the ruble. Has anything changed since that time? Things have changed, but in some places, unfortunately, not for the better.

Readers will remember from that article how artel bosses gain their wealth. One of the sources of this unaccounted wealth was the duping of new workers with illegal probationary periods, lasting up to a half year. During this period, the new worker was paid a probationary rate, although he worked 12 to 14 hours like everyone else. The difference between the probationary rate and the true salary was tens of rubles per day, which were confiscated by the artel bosses.

Illegal probationary periods are still being used, but some artels have reached new heights in these practices: they assign a labor participation coefficient to each new worker. This would seem to be a very modern, scientific practice. But the coefficient is about 0.3, which results in wages which are even below the probationary rates. Here's artel democracy in action for you.

At a state-run enterprise, wages must be paid on time. Any problems in this regard will lead to serious conflicts and the intervention of the law enforcement agencies.

In the artels, late payments to workers have become systematic. On the day of the meeting, Zabaykalzoloto Association alone had not settled up with 1500 workers for the past season. There are artel workers who have not received their due even for 1986.

Have the local authorities, Glavalmazzoloto inspectors or the procurator's office intervened in this sorry state of affairs? Not at all. They defer to one another and itemize the facts in reports, but they don't actually want to act to protect human rights. It's as if democracy doesn't need any protection, or else democracy applies only to the artel management, and not to those who are digging away in the taiga.

#### Fact From the Stenographer's Record

The problem of protecting gold and preventing theft is still acute. There have been cases where the people mining the gold have colluded with those who are responsible for safeguarding it and preventing theft. This arrangement allowed 28 kg of gold to be stolen in Tajikistan.

Here's the paradox: gold is being stolen, but no disappearances have been recorded at any artels!

This might seem impossible to you, or at least very improbable.

Some writers, including those from the procurator's office, are trying to break down an unlocked door. They are going about seriously and verbosely proving that they just want to be rich, while SOTSIALISTICHESKAYA INDUSTRIYA wants everybody to be dirt poor. We are going to have to vex these vehement polemicists: we are also in favor of prosperity.

But there is wealth and then there is wealth. One person might be satisfied with his or her earnings, while another might consider the several-thousand-ruble "chunk" typically earned by an artel worker to be too small. These are the people who steal. They get into conflicts with the Criminal Code only because they want to be even wealthier. In recent years, about 300 kg of stolen gold has been recovered. But how much stolen gold has not been recovered, and has instead ended up on the black market, or is still being held in strong boxes? Nobody knows, including people in the Ministry of Internal Affairs and the USSR Procurator's Office. We can only guess that very, very much has not been recovered.

Imagine how much these crooks could have gotten for 300 kg when a gram of gold fetches 70-90 R on the black market.

In recent years, over 30 artel chairmen, deputy chairmen and executives of mining enterprises have ended up in court for breaching the Criminal Code in their unrestrained attempt to get rich. The normal salaries of these people allowed them to live pretty well to begin with, but they preferred bribes, plunder and receiving stolen gold.

We'll not rush to attribute this desire for wealth to a rebellious spirit born of social injustice. Because if we're looking now for scandalous social injustice, then we can't overlook the lot of production workers in gold artels.

There are considerable safeguards to protect the gold that's produced, but the thefts continue. Why? Let's call a spade a spade. These times of sober evaluations and calculations require no less. If gold is being stolen by the gram and even kilogram in Magadan and Chita, in Yakutiya and Uzbekistan and in the Altay and the Urals, then that means that someone is personally profiting from a continuation of the situation. This someone must be a person who is capable of protecting and maintaining this situation. I think you will agree that there is some basis for this hypothesis. Actually, if the entire industry is plagued by thefts of the country's monetary wealth, and neither the almighty Procurator's Office nor the no-less-mighty Ministry of Internal Affairs can even say how much is going into the pockets of the gold mafia, this means that there are mighty forces at work, and mighty protectors to ensure that these forces can continue draining away noble metals and selling them on the black market. Unfortunately, these forces are able to buy silence and to block all possible leaks of information about this system.

There's one argument in favor of this hypothesis. It sounds ridiculous, but according to information from the USSR Procurator's Office, the country has only one

device (that is, there is only one specimen in existence) to detect gold hidden on a person or in a suitcase. For some reason, this device is at an airport in Central Asia.

Apparently, someone is very interested in making sure that there aren't more of these devices around. After all, you can't possibly compare the value of 300 kg of stolen gold with the cost of this one single device. We need to find out who it is that doesn't want series production of these devices, and then we can say exactly who it is that "wants to be rich."

A year has passed. As the participants at the meeting noted, much has been done to correct the situation. As we can see, new facts have come to light and different violations have been uncovered. But the violations are continuing. It was as if there had never been an article entitled "No, You're Not Dreaming!", as if there had never been a Central Committee decree. The only difference, perhaps, is that now it's not journalists who are naming the facts and the names, it's the procurators and the gold-production enterprise executives who are doing it.

The conclusions reached in the CPSU Central Committee decree a year ago still apply. No one at the meeting of the USSR Glavalmazzoloto collegium voice a different opinion. This means that we must work long and hard to fulfill this decree completely. After all, these deficiencies and oversights are very serious. We need to unite all efforts, including those of law enforcement agencies, the mass media, oversight agencies and party and industry organizations, to put an end to these negative phenomena in the industry as quickly as possible. We are calling for such a consolidation of efforts, and we call on our partners to join us.

**Controversy Delays Introduction of Superplasticizer for Concrete**  
*18420123 Baku BAKINSKIY RABOCHIY in Russian*  
*4 Jan 89 p 3*

[Article by M. Guseynov]

[Abstract] The article reports on problems which are holding up introduction of "additive 40-03", a superplasticizer for concrete, and of a process for producing this substance.

"Additive 40-03" was synthesized in the USSR as a domestic counterpart of a Japanese superplasticizer based on a naphthalene polymer, it is recalled. During the early 1980s, a group of associates of the Azerbaijani Academy of Sciences' Institute of Petrochemical Processes (INKhP) worked on improving the process for production of the superplasticizer. This group was headed by Shakhrib Aliyev, corresponding member of the Azerbaijani academy. A process which he and his colleagues proposed uses raw materials which are plentiful, and it is relatively safe from the ecological standpoint, it is claimed. A diesel-fuel component of high quality can be obtained from by-products of this process. Aliyev became a deputy director of INKhP in 1983 and a scientific project director of a state program called "Stroyprogress-2000" (construction progress-2000) in July of 1988.

The general director of the All-Union Reinforced-Concrete Scientific Production Association, a commission of the USSR Academy of Sciences' Institute of Petrochemical Synthesis, experts of the USSR Ministry of the Petroleum-Refining and Petrochemical Industry, and Vagab Safarovich Aliyev, a former director of INKhP and now a consultant to this institute, are quoted in praise of S. Aliyev's professional competence and the process which he and his colleagues developed. V. Aliyev mentioned that this process has been introduced successfully at the Novomoskovsk Petrochemical Complex. On the basis of the superplasticizer "40-03", Shakhveran Babayev, a Moscow Scientist, and his colleagues reportedly have developed a binder with low water requirements which makes it possible to obtain concrete with a minimal quantity of cement. Concrete products whose strength is said to be almost twice as high as the maximum achieved previously in world practice have been obtained in experiments with this binder.

The author relates that opposition to introduction of S. Aliyev's developments has come chiefly from heads of the republic Academy of Sciences and officials of INKhP, who have claimed that the superplasticizer "40-03" does not meet basic requirements for industrial use and that the process for producing it requires further perfecting. E. Salayev, president of the Azerbaijani academy, rebuked Aliyev for 'scientific speculation'. Aliyev was removed from his administrative position at the petrochemical-processes institute in 1986, by a decision of a joint meeting of the academy's presidium and Communist Party committee. It is implied that this decision was influenced by elements which were supporting a candidate other than Aliyev for the position of director of INKhP. Yu. P. Batalin, chairman of the USSR State Construction Committee, reportedly has appealed to the Azerbaijani republic's leaders on behalf of Aliyev, and steps to speed introduction of the superplasticizer production process were called for at a conference which took place in Moscow in the summer of 1988.

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**Reserves for Increasing Effectiveness of Metallurgical Slag Utilization**  
*18420051e Dnepropetrovsk METALLURGICHESKAYA I GORNORUDNAYA PROMYSHLENNOST: NAUCHNO-TEKHNICHESKIY I PROIZVODSTVENNYY SBORNIK in Russian*  
*No 3, Jul-Sep 88 pp 56-57*

[Article by Yu. A. Dolgorukov, G. M. Komyagin, and A. A. Aleshin, Donetsk Scientific Research Institute of Ferrous Metallurgy]

[Abstract] Significant profitability reserves can be mobilized in ferrous metallurgical plants by complete utilization of metallurgical slags and the transition of enterprises to operation without slag heaps. In 1986, in the Ukraine, 100.4 percent of blast furnace slags and 69.8 percent of steelmaking slags were reprocessed for further use. Utilization of metal extracted from slag resulted in a savings of over 1.7 million tons of primary iron ore, valued at over 21 million rubles. Sale of slag products yielded a profit of 5.7 million rubles at a profit rate of 14.3 percent in 1986. However, some enterprises still do not make full use of this valuable source of additional profit. Improvements in technology and increased awareness will lead to continued improvements in the future.

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